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The Nature Conservancy's Emiquon Preserve

Fish and Aquatic Vegetation Monitoring

Annual Report

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Floodplain restoration monitoring of the aquatic vegetation and fish communities of The Nature Conservancy's Emiquon Preserve 2007-2014

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Disclaimer

Under contract with The Nature Conservancy (TNC), fish and aquatic vegetation monitoring (2007-present) was conducted on Thompson and Flag lakes of TNC's Emiquon Preserve by the Illinois Natural History Survey, Illinois River Biological Station (INHS-IRBS) in order to evaluate a series of key ecological attributes (KEA) relevant to restoration success. This report presents a summary of data collected in 2013. The findings, conclusions, and views expressed herein are those of the researchers and should not be considered as the official position of TNC or the INHS.

Executive Summary

Key Ecological Attributes (KEA's) for the fish and aquatic vegetation communities have been identified as indicators of the condition and success of the restoration efforts at Thompson and Flag lakes of The Nature Conservancy's Emiquon Preserve. A total of 19 KEA criteria related to the aquatic vegetation and fish communities were monitored monthly between 4/15/2013-10/25/2013. Of those goals set by the Emiquon Science Advisory Council, 15 were met in 2013.

The 2013 water transparency values were within the desired range (Secchi depths no less than half the maximum water depth when a site is ≤1.5 m deep). When 2013 results are compared to 2012, we see that the mean monthly transparencies for April-May were less than the same period in 2012 and transparencies during June-October in 2013 were greater than the corresponding in 2012.

Two invasive aquatic plants (i.e. Eurasian watermilfoil and curly-leaf pondweed) were among the many aquatic plant species collected in 2013. Eurasian watermilfoil was found at fewer sites and at a lower density than in 2012. Curly-leaf pondweed was also collected at fewer sites than in 2012, but at the same density during both years. Aquatic vegetation monitoring in 2013 represents the first year since monitoring began that Eurasian watermilfoil rake densities displayed a reduced density. Invasive aquatic plant species will continue to be monitored closely.

The fish community in 2013 continued to be dominated by native species. Despite this, the KEA goal of collecting ≥25 native fish species was not met. More time may be needed for less abundant species to become established and/or additional stocking may be necessary in order to meet this goal. Gizzard shad dominated our catches in 2013. Catches of desirable native fishes including bowfin and shortnose gar were the highest ever observed at the Emiquon Preserve. Of the 19 fish species collected, only one non-native species, the common carp was collected and will continue to be monitored closely.

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Introduction

Historically, Thompson and Flag lakes were two of the most productive backwater lakes in the Illinois River Valley (Havera et al. 2003). However, both lakes were disconnected from the Illinois River and reduced to agricultural drainage ditches in the early 1900s. These former floodplain lakes became one of the largest farms in Illinois and remained disconnected behind levees and in agricultural production until 2006. The Nature Conservancy purchased this property in 2000 and began aquatic restoration in 2007. A group of Key Ecological Attributes (KEA's) were developed in 2004 by the Emiquon Science Advisory Council (i.e. The Nature Conservancy and partners) to serve as the driving management tool, success criteria, and a basis for monitoring endpoints used in this document to describe the Emiquon restoration. Prior to the 2007 restoration, rotenone was applied to the agricultural drainage ditches to eradicate all fish species and allow a new start. The site was allowed to naturally fill through precipitation and >30 native fish species were stocked based on historical records of both lakes (Havera et al 2003). The Illinois Natural History Survey's Illinois River Biological Station has been monitoring the aquatic vegetation and fish communities since 2007. The resulting data is used to evaluate whether the project has been successful in restoring the property based on KEA goals (VanMiddlesworth et al. 2014).The knowledge gained may aid in future management efforts at the Emiquon Preserve and other floodplain restoration efforts.

Sampling Effort

Aquatic Vegetation Sampling and Gear Effort - Thompson/Flag lakes

We conducted aquatic vegetation sampling monthly at 30 random sites May-September at both Thompson and Flag lakes (Table 1). Thompson and Flag lakes were sampled as one water body, but spatially stratified into north, middle, and south units. We also sampled 60 random sites in July and August during the peak of the growing season. The density of submersed aquatic vegetation (SAV) is based on percent coverage on a vegetation rake, while emergent, non-rooted floating-leaved, and rooted floating-leaved aquatic vegetation density is estimated by percent cover observed within a 2 m circle around the boat. All aquatic vegetation data was collected according to Yin et al. (2000).

Aquatic Vegetation Collected and Observed Species - Thompson/Flag lakes

We collected and/or observed 15 aquatic plant species (submersed, emergent, and non-rooted floating-leaved, and rooted floating-leaved) at 167 out of 210 random sites in 2013 (Table 2, 3). Community composition at vegetated sites was dominated by submersed aquatic vegetation (i.e. American pondweed *Potamogeton nodosus*), followed by 10 other submersed aquatic plant species including a submersed aquatic macroalgae known as *Chara* spp. (stoneworts) (Pelechaty and Pukacz 2006). Emergent aquatic vegetation community composition at vegetated sites was minimal, but included narrow-leaved cattail *Typha angustifolia*. One non-rooted floating-leaved aquatic plant known as Lemnaceae was represented by *Lemna* spp. Rooted floating-leaved species were represented by creeping water primrose *Ludwigia peploides* and American lotus *Nelumbo lutea*. Curly-leaf pondweed *Potamogeton crispus* and Eurasian watermilfoil

Myriophyllum spicatum were the only non-native species of aquatic plants collected in 2013 (Table 3).

Fish Sampling and Gear Effort - Thompson Lake

We conducted monthly fish sampling April-October at Thompson Lake using a multiple gear approach at both random and fixed sites (Table 1). Flag Lake was not sampled due to shallow water depth and dense aquatic vegetation beds that foul our sampling gears. Also, we believe that Thompson Lake gives us a better representation of the fish community. Fish sampling did not use the spatially stratified approach of the aquatic vegetation sampling and consisted of 24 electrofishing runs (15 minutes each) (4 sites were not sampled in April 2013 because of inaccessibility due to historic flooding), 28 fyke net sets (24 hours each), and 28 mini-fyke net sets (24 hours each) at shoreline or pseudo-shoreline (used for shoreline gear) sites. Seven tandem fyke net sets (24 hours each) and seven tandem mini-fyke net sets (24 hours each) were also deployed at open water (pelagic) sites. All gears were fished according to Gutreuter et al. (1995).

Total Fish Catch - Thompson Lake

We collected 15,489 fishes representing 19 species and 9 families in 2013. Community composition was dominated by gizzard shad *Dorosoma cepedianum* followed by black crappie *Pomoxis nigromaculatus*, unidentified young-of-the-year (YOY) *Lepomis* spp. (bluegill *L. macrochirus* or pumpkinseed *L. gibbosus* with lengths <40 mm), and bluegill. Approximately 16 other fish species made up the remainder of the total catch. Common carp *Cyprinus carpio* were the only non-native species collected in 2013. Other fish species that either survived the rotenone or were unintentionally stocked included gizzard shad, black bullhead *Ameiurus melas*, yellow bullhead *A. natalis*, shortnose gar *Lepisosteus platostomus*, unidentified Catostomidae spp. (bigmouth buffalo *Ictiobus cyprinellus* or smallmouth buffalo *I. bubalus*) and a *Lepomis* spp. hybrid (bluegill x pumpkinseed) (Table 4).

Catch-per-Unit Effort (CPUE) - Thompson Lake

We collected 14 fish species while electrofishing in 2013, which comprised 53% of the total catch by all gears. Community composition was dominated again by gizzard shad, followed by largemouth bass *Micropterus salmoides*, golden shiner *Notemigonus crysoleucas*, and unidentified young-of-the-year (YOY) *Lepomis* spp. (bluegill or pumpkinseed with lengths <40 mm). Approximately 11 other fish species made up the remainder of the catch while electrofishing. Common carp were the only non-native fish species collected while electrofishing in 2013. Other fish species collected while electrofishing in 2013 that either survived the rotenone or was unintentionally stocked included gizzard shad. Catch rates of different fish species varied by gear (Table 5, 6).

Key Ecological Attributes (KEA's) Results - Thompson/Flag lakes

Of 19 relevant KEA criteria related to the aquatic vegetation and fish communities, 19 KEA's were addressed and the goals of 15 were met in 2013.

Submersed Aquatic Vegetation

KEA 1: Underwater Irradiance
Indicator: Secchi disc transparency
Desired Range: Submersed aquatic vegetation target areas, Secchi disc reading ≥half the maximum water depth in ≤1.5 m, measured during late spring/early summer
Goal Met: Yes

Secchi disc transparencies taken from all aquatic vegetation and fish monitoring site littoral areas with ≤1.5 m water depth April-May were ≥half the maximum water depth 53% of the time in 2013. Those collected June-October were ≥half the maximum water depth 76% of the time in 2013. Fixed Secchi disc transparencies collected monthly at three fixed sites (North YSI pole, pumphouse mouth, pumpstation) and two fixed pelagic fish sites (tandem fyke, tandem mini-fyke) had a mean of 34.8 cm during April-May and 51.8 cm during June-October in 2013.

KEA 2: Hydrology
Indicator: Water depth
Desired Range: Rate of water rise does not exceed 1.5 cm/day during the growing season (May-September); Water level fluctuations (rise) do not exceed 1 m total (May-September)
Goal Met: Yes; Yes

We only used water gauge data that was collected from the Emiquon pumphouse on a day to day basis and excluded all days when no data was collected which indicated a water rise ≥1.5 cm/day during the growing season (May-September) only 14% of the time in 2013. Increases in water level fluctuation did not exceed 1 m total May-September, 2013 (Figure 1).

KEA 3: Community Composition
Indicator: Percent natives vs. invasives
Desired Range: ≤10% exotics, e.g., Eurasian watermilfoil *Myriophyllum spicatum*, curly-leaf pondweed *Potamogeton crispus*
Goal Met: No

Of the total aquatic vegetation (submersed, emergent, and floating-leaved) collected and observed at random sites during May-September, 2013, 15.8% was composed of exotic species: Eurasian watermilfoil (15.6%) and curly-leaf pondweed (0.2%) (Table 3).

Emergent/ Floating-leaved Vegetation

KEA 4: Hydrology
Indicator: Stable water depth
Desired Range: Rate of water rise does not exceed 1.5 cm/day during the growing season (May-September); Water level fluctuations (rise) do not exceed 1 m total (May-September)
Goal Met: Yes; Yes

We only used water gauge data that was collected from the Emiquon pumphouse on a day to day basis and excluded all days when no data was collected which indicated a water rise ≥1.5 cm/day during the growing season (May-September) only 14% of the time in 2013. Increases in water level fluctuation did not exceed 1 m total May-September, 2013 (Figure 1).

KEA 5: Community Composition
Indicator: Percent natives vs. invasives
Desired Range: ≥90% dominance by native species
Goal Met: Yes

There were no invasive emergent or floating-leaved aquatic plant species observed in 2013 (Table 3).

Fish (Riverine and Backwater)

KEA 6: Fish Community Assemblages
Indicator: Number of native species populations
Desired Range: ≥25 native species represented (very good = ≥30 native species)
Goal Met: No

19 fish species (18 native and 1 non-native) were collected in 2013. (Table 4).

KEA 7: Fish Community Assemblages
Indicator: Number of native species populations
Desired Range: Native species ≥50% of number; Native species ≥50% of total biomass
Goal Met: Yes

Native fish species dominated the fish community representing 99.4% of the total catch and 81.2% of the total biomass in 2013 (Table 4).

KEA 8: Fish Community Composition
Indicator: Native predatory fish population
Desired Range: Very good = ≥100 largemouth bass *Micropterus salmoides* CPUE while electrofishing and bowfin *Amia calva* present, good = 75-100 largemouth bass CPUE, fair = 50-75 largemouth bass CPUE, poor = <50 largemouth bass CPUE
Goal Met: Yes (fair)

Largemouth bass was the dominant predator collected with a CPUE of 61 fish/hour (450 total collected by all gears) while electrofishing in 2013. Of the other potential predators, bowfin were present with a total of 59 collected along with 18 shortnose gar and 14 spotted gar *Lepisosteus oculatus* in 2013 (Table 4, 5). Criteria for Largemouth Bass CPUE being considered very good, good, fair, and poor was provided and used by Illinois Department of Natural Resources district fisheries biologists.

KEA 9: Spawning
Indicator: Water dissolved oxygen
Desired Range: 4 ppm oxygen (very good = ≥5 ppm and <200% saturation oxygen)
Goal Met: Yes (very good)

Monthly mean dissolved oxygen concentrations decreased from 9.5 ppm to 3.7 ppm during April-September, but increased to 10.1 ppm in October, 2013. All monthly mean dissolved oxygen concentrations were above the desired range except for September in 2013 (Figure 2). Percent saturation was not measured in 2013.

KEA 10: Spawning
Indicator: Substrate variability and structure (large woody debris)
Desired Range: Subset representing several of the following types present: diverse shoreline, shade, fallen trees, open areas, and submerged plants (very good = all types present)
Goal Met: Yes (very good)

During 2013, there was an abundance of diverse shoreline habitats, open areas, and emergent, floating-leaved, and submersed aquatic vegetation. There was minimal shading by trees, but shade was made abundant by aquatic vegetation. Large woody debris was minimal.

KEA 11: Spawning
Indicator: Frequency of April/May connection to the river
Desired Range: Every three years for long-lived species, more frequently for short-lived species (very good = annual connection)
Goal Met: Yes, (good)

The Emiquon levee was breeched resulting in a one-way connection during a historic flood event during April-May, 2013. Soon after, the river crested and Emiquon was disconnected for the remainder of the year.

KEA 12: Nursery
Indicator: Accessibility for riverine fish
Desired Range: Presence of YOY freshwater drum *Aplodinotus grunniens*, goldeye *Hiodon alosoides*, bigmouth buffalo *Ictiobus cyprinellus* (very good = all of the above plus paddlefish *Polyodon spathula*)
Goal Met: Yes

Young-of-year (YOY) freshwater drum, goldeye, and paddlefish were absent in our 2013 collections. However, we collected 3 unidentified Catostomidae spp. (likely bigmouth or smallmouth buffalo) in 2013 (Table 4).

KEA 13: Nursery
Indicator: Native fish larvae
Desired Range: Dominance of native species
Goal Met: Yes

All fish were considered young-of-the-year (YOY) if they measured <100 mm in total length, except YOY unidentified *Lepomis* spp. (bluegill or pumpkinseed <40 mm) and included black crappie, bluegill, gizzard shad, largemouth bass, pumpkinseed, bluegill x pumpkinseed hybrid, unidentified *Ameiurus* spp., unidentified Catostomidae spp. (likely bigmouth or smallmouth buffalo), warmouth *Lepomis gulosus*, white crappie *Pomoxis annularis*, and yellow bullhead. Other species including emerald shiner *Notropis atherinoides*, golden shiner, mud darter *Etheostoma asprigene*, and starhead topminnow *Fundulus dispar* may be considered adults at <100 mm. Native fish species dominated comprising 99.8% of the total YOY catch. Gizzard shad dominated the YOY catch and only one species of non-native larval fish was collected in 2013, which consisted of 5 YOY common carp <100 mm (Figure 3-11).

KEA 14: Feeding
Indicator: Presence of adults in good condition
Desired Range: Mean relative weights 90-110%
Goal Met: Yes

Mean relative weights of black crappie (100%), bluegill (99%), pumpkinseed (104%), and largemouth bass (93%) were well within the desired range. Undesirable fish species, such as gizzard shad, had mean relative weights of 91% (Table 7, Figure 12-16).

KEA 15: Feeding
Indicator: Distribution of abundant aquatic vegetation
Desired Range: 25-40% of the littoral area contains abundant vegetation during July-August
Goal Met: Yes

Out of all littoral (≤1.5 m water depth) aquatic vegetation and fish sampling sites during July-August, 100% displayed abundant aquatic vegetation in 2013 (Figure 17).

KEA 16: Over-wintering
Indicator: Percent of deep (oxygen rich) water
Desired Range: Water depth (5% >3 m, 10% 2-3 m, 25% 1-2 m, 60% <1 m); Dissolved oxygen (4.0-6.0 ppm at 2 m depth); Water temperature ≥1 °C (34 °F) at 2 m depth
Goal Met: Yes; Yes; Yes

Percent of deep water at Thompson and Flag lakes was calculated in 2013 using a bathymetry map at 432 ft asl (Figure 17). Approximately 9.5% of Thompson and Flag lakes showed water depths >3 m, 12.9% at 2-3 m, 35.8% at 1-2 m, and 44.8% at <1 m in 2013. Dissolved oxygen (ppm)/ temperature (°C) profiles were collected at ten fixed sites on Thompson and Flag lakes targeting shallow and deep water ditch areas during March 12, 2013 to evaluate over-wintering fish habitat (Figure 18). Dissolved oxygen concentrations at all ten fixed sites exceeded the desired range of 4.0-6.0 ppm at ≥2 m water depth and temperatures at all sites from surface to bottom exceeded the desired range of ≥1 °C at ≥2 m water depth (Figure 19).

KEA 17: Over-wintering
Indicator: Presence of backwater species
Desired Range: Water temperature ≥34 °F based on the needs of freshwater drum (Bodensteiner & Lewis 1992)
Goal Met: Yes

Water temperatures collected at Thompson and Flag lakes during March 12, 2013 at all fixed dissolved oxygen (ppm)/temperature (°C) profile sites and during March 28, 2013 at all fixed electrofishing sites were ≥34 °F (Figure 18, 19, 20).

KEA 18: Over-wintering
Indicator: Concentrations of over-wintering native species
Desired Range: Maximum electrofishing CPUE (hot spots) for wintering native species exclusive of gizzard shad *Dorosoma cepedianum* and minnows >1500 individuals/hr and >5 species (very good = >2000/hr)
Goal Met: No

Ten fixed electrofishing sites in the pumphouse ditch were sampled at Thompson and Flag lakes during March 28, 2013 to evaluate over-wintering fish habitat. We collected 190 total fish comprising 10 species and 4 families (Figure 20) (Table 1A).

KEA 19: Feeding
Indicator: Secondary production delivered to the river
Desired Range: Loading and timing of plankton, macroinvertebrates, and fish delivered to the river
Goal Met: No

The Emiquon levee was breeched resulting in a one-way connection during a historic flood event during April-May, 2013. Soon after, the river crested and Emiquon was disconnected for the remainder of the year. Secondary production was not delivered to the river.

Discussion of KEA's - Thompson/Flag lakes

Submersed Aquatic Vegetation Community

A majority of the water transparencies that were measured by a Secchi disc collected at appropriate monitoring sites were within the desired range stated by KEA 1 (Secchi depths no less than half the maximum water depth when a site is ≤1.5 m deep). When 2013 results are compared to 2012, we see that the mean monthly Secchi disc transparencies during April-May were lower in 2013 ($n = 17$, $df = 15$, $t = 0.2$, $p = 0.84$) and higher during June-October in 2013 ($n = 50$, $df = 48$, $t = 3.1$, $p = <0.05$).

Daily water level fluctuations collected from the Emiquon pumphouse water gauge during 2012-2013 (May-September) were within the desired ranges stated by KEA 2 (rate of water rise does not exceed 1.5 cm/day; water rise does not exceed 1 m total) each year. Water level was low in 2012 because of evaporation, but increased in 2013 due to precipitation and a historic flood event. KEA 2 will become more applicable once the Emiquon Preserve is reconnected to the Illinois River.

Although the aquatic vegetation community was dominated by native plant species, it was composed of greater than 10% exotic plant species (plant density). Two invasive aquatic plants (i.e. Eurasian watermilfoil and curly-leaf pondweed) were the only invasive aquatic plant species collected. Eurasian watermilfoil was collected at fewer sites and at a lower density in 2013 (101 out of 210 sites; 15.6%) than in 2012 (136 out of 210 sites; 24.0%) (Figure 21). This was the first year since monitoring began that Eurasian watermilfoil rake densities declined. Curly-leaf pondweed was collected at fewer sites in 2013 (5 out of 210 sites) than in 2012 (8 out of 210 sites), but at the same density during both years (0.2%) (Figure 22). This may be a result of competition with other aquatic plant species such as Eurasian watermilfoil. Also, curly-leaf pondweed seeds and vegetative parts are consumed by dabbling and diving ducks, as well as coots (Catling and Dobson 1985).

Emergent/Floating-leaved Vegetation

As discussed for KEA 2, daily water level fluctuations collected from the Emiquon pumphouse water gauge during 2012-2013 (May-September) were within the desired ranges stated by KEA 2 and 4 (rate of water rise does not exceed 1.5 cm/day; water rise does not exceed 1 m total) each year. KEA 2 and 4 will become more applicable once the Emiquon Preserve is reconnected to the Illinois River.

No invasive emergent, non-rooted floating-leaved, or rooted floating-leaved aquatic plant species were not observed in 2013. All samples represented native species meeting the goal of KEA 5 (≥90% dominance by native species). American lotus was observed in 34 large beds within the Emiquon Preserve (17 in the north portion of Thompson Lake, 9 in the middle portion of Thompson and Flag lakes, and 8 in the south portion of Thompson and Flag lakes) (Figure 23).

Fish (Riverine and Backwater)

Native species dominated the fish community in 2013 comprising 99.4% of the total catch and 81.2% of the biomass. We collected 19 species (18 native, 1 non-native) in 2013 of which gizzard shad was the most abundant with 7,442 fish comprising 48.0% of the total fish collected in 2013. This represented the highest catch of gizzard shad observed at the Emiquon Preserve. Gizzard shad catch with lengths 10-100 mm in 2013 (7,230 fish) increased nearly six times that of 2012 (1,272 fish). Increased catch of gizzard shad with a majority of the fish being 10-100 mm may be attributed to a successful spawning event in 2013. Common carp were the only invasive fish species collected during April-October, 2013 (n = 92; April = 8, May = 13, June = 39, July = 12, August = 8, September = 8, and October = 4). Common carp were collected in all gears except the tandem mini-fyke net sets. Thirty-five percent of common carp (32 out of 92) were collected at the mini-fyke net sites in the littoral zone of Thompson Lake during April-October, 2013. Common carp lengths ranged from 20-740 mm. All common carp collected were removed from the system (Figure 24).

Gizzard shad also dominated the total electrofishing catch with a CPUE of 1,218 fish/hr in 2013. Largemouth bass CPUE which were standardized to account for the difference in surface area due to changing water levels during 2012-2013, was fair with a total of 61 fish/hr while electrofishing in 2013 down from a good 91 fish/hr in 2012 (n = 12, df = 10, t = 2.7, p = 2.22). Note that no data from the month of April is excluded because no electrofishing was conducted due to a historic flood event which eliminated access to the Emiquon Preserve. Largemouth bass was the dominant predator collected in 2013 (450 total collected by all gears), down from 1,802 in 2012. Reduced catches of largemoth bass may be due to higher water levels in 2013 which may have caused them to become less concentrated. Bowfin collections increased from 29 in 2012 to 59 in 2013. The total number of bowfin (n = 59) and shortnose gar (n = 18) collected in 2013 represented the highest catches observed at the Emiquon Preserve. All bowfin collected ranged from 400-690 mm in total length while all shortnose gar ranged from 470-670 mm in total length. Increased catch rates of larger specimens for these species may be due to introduction by a historic flood event in 2013.

Mean monthly dissolved oxygen concentrations were in the desired range except for during the month of September. Mean dissolved oxygen concentrations taken from all aquatic vegetation and fish sampling sites decreased from 9.5 ppm to 3.7 ppm during April-September and then increased to 10.1 ppm in October, 2013. Diverse shoreline habitats, open areas, and emergent, floating-leaved, and submersed aquatic vegetation were abundant in 2013. There was minimal shading by trees, but shade from submersed, emergent, non-rooted floating leaved, and rooted floating leaved aquatic plant species was made abundant. Large woody debris was minimal, but some were present near ditch and the old gravel pit areas in 2012. The Emiquon levee was breeched resulting in a one-way connection during a historic flood event during April-May, 2013 which partially met the goal of KEA 11 (spawning habitat availability). Soon after, the river crested and Emiquon was disconnected for the remainder of the year. Also, nursery habitats and accessibility for riverine fishes (KEA 12) was temporarily applicable during the 2013 flood event. Young-of-year (YOY) freshwater drum, goldeye, and paddlefish were absent in our 2013 collections. However, we collected 3 unidentified Catostomidae spp. (likely bigmouth or smallmouth buffalo) in 2013.

No ichthyoplankton tows were conducted in 2013 because aquatic vegetation and algae clogged the gear in previous attempts. KEA 13 was addressed in 2013 using total catch of YOY species. All fish species were considered YOY if they measured <100 mm, except for YOY unidentified *Lepomis* spp. (bluegill or pumpkinseed <40 mm) and included black crappie, bluegill, gizzard shad, largemouth bass, pumpkinseed, bluegill x pumpkinseed hybrid, unidentified *Ameiurus* spp., unidentified Catostomidae spp. (likely bigmouth or smallmouth buffalo), warmouth, white crappie, and yellow bullhead. Other species including emerald shiner, golden shiner, mud darter, and starhead topminnow may be considered adults at <100 mm. YOY unidentified *Ameiurus* spp. most likely represent black or brown bullhead. Black and brown bullhead ≥10 mm can be distinguished from yellow bullhead by pigmented chin barbels (Simon and Wallus, 2004). Native fish species dominated comprising 99.8% of the total YOY catch. Gizzard shad dominated the YOY catch and only one species of non-native larval fish was collected in 2013, which consisted of 5 YOY common carp <100 mm (20-70 mm).

We used published standard weight equations (Neumann, Guy, and Willis 2012) to determine relative weights of fish species collected in 2013. Mean relative weights of black crappie, bluegill, pumpkinseed, and largemouth bass were well within their desired ranges. Black crappie mean relative weight was lower in 2013 (100% of the standard) than in 2012 (105% of the standard) ($n = 899$, $df = 897$, $t = 3.2$, $p = 1.96$). Bluegill mean relative weight was lower in 2013 (99% of the standard) than in 2012 (103% of the standard) in 2012 ($n = 1521$, $df = 1519$, $t = 0.8$, $p = 1.96$). Pumpkinseed mean relative weight increased from 103% of the standard in 2012 to 104% of the standard in 2013 ($n = 190$, $df = 188$, $t = 0.2$, $p = 0.84$). Largemouth bass mean relative weight was lower in 2013 (93% of the standard) than in 2012 (95% of the standard) ($n = 719$, $df = 717$, $t = 3.4$, $p = 1.96$). Mean relative weight of gizzard shad increased from 90% of the standard in 2012 to 91% of the standard in 2013 ($n = 559$, $df = 557$, $t = 0.4$, $p = 0.72$). The gizzard shad population will continue to be monitored more closely because they have the potential to induce a trophic cascade in lentic ecosystems. The most likely cascade would be that gizzard shad feed on zooplankton, which may control phytoplankton dynamics through predation. Relative weight outliers were not included in our analyses and were most likely due to inaccurate weight measurements caused from wind and wave action.

All littoral (≤1.5 m water depth) aquatic vegetation and fish sampling sites during July-August, 2012-2013 displayed abundant aquatic vegetation exceeding the desired range of KEA 15 (25-40% of the littoral area containing abundant vegetation during July-August).

KEA 16 was addressed on March 12, 2013. Dissolved oxygen (ppm)/ temperature (°C) profiles were collected at ten fixed sites on Thompson and Flag lakes targeting shallow and deep water ditch areas to evaluate over-wintering fish habitat. Percent of deep water at Thompson and Flag lakes was calculated in 2013 using a bathymetry map at 432 ft asl and approximately 9.5% of Thompson and Flag lakes showed water depths >3 m, 12.9% at 2-3 m, 35.8% at 1-2 m, and 44.8% at <1 m in 2013. These results suggest that Thompson and Flag lakes were made up of primarily more deep water habitat than desired. Dissolved oxygen concentrations at all ten fixed sites exceeded the desired range of 4.0-6.0 ppm at ≥2 m water depth and temperatures at all sites from surface to bottom exceeded the desired range of ≥1 °C at ≥2 m water depth. Therefore, there is plenty of over-wintering habitat available in the ditches. Over-wintering fish habitat was not measured due to a lack of appropriate gear in 2012.

Water temperatures collected at the Emiquon Preserve on March 12, 2013 to evaluate the quality of over-wintering fish habitat at ten fixed sites were ≥34 °F from surface to bottom meeting the goal of KEA 17 (water temperature ≥34 °F). In addition, ten fixed electrofishing sites in the pumphouse ditch were sampled at Thompson and Flag lakes during March 28, 2013 to evaluate the use of over-wintering fish habitat. We collected 190 total fish comprising 10 species and 4 families which does not meet the goal of KEA 18. However, the pulsed-DC electrofishing boat is only effective to a maximum depth of 6 feet and the pumphouse ditch is >6 feet deep. Thus, many over-wintering fish that may have been present were not accurately sampled. Perhaps in 2014, deep water gears such as a tandem fyke net, tandem mini-fyke net, or hoop net would be a better choice to evaluate KEA 18 more effectively. Over-wintering fish habitat was not measured in 2012 due to a lack of gear. We could not quantify secondary production delivered to the Illinois River because no pumping occurred from 2012-2013 and the connection during the flood event in 2013 was only one-way (river to preserve). Therefore, we could not evaluate KEA 19 during these years but will measure it once the Emiquon Preserve is connected to the Illinois River.

Bycatch

Incidental turtle bycatch from Thompson Lake consisted of 2 western painted turtles *Chrysemys picta belli*. Turtle bycatch decreased from 8 individuals in 2012. All turtles were returned to the water after recording carapace length and sex.

We collected 6 unidentified mussel spp. (most likely floater spp.) while conducting fish and aquatic vegetation monitoring in 2013. Four mussels were collected in a tandem mini-fyke net (10 mm each), another was collected in a mini-fyke net (30 mm), and one more was collected with an aquatic vegetation rake while collecting aquatic vegetation (10 mm). The total number of mussels collected in 2013 decreased from 9 mussels collected in 2012. All mussels collected were returned to the water. No snakes were captured in 2013.

Additional Information

The Illinois River experienced historic record flooding in April-May, 2013 that overtopped the south levee of the Emiquon Preserve. Flood water was also introduced to the Emiquon Preserve through the north highway underpass. This was the first time that the Illinois River has entered the Emiquon Preserve since being disconnected in the early 1900s. TNC seined the south end of the Emiquon Preserve while floodwater overtopped the levee to examine the composition of any fish introductions. Fish observed were composed of both native and non-native species including a number of common carp (Table 1B). IDNR district fisheries biologist Rob Hilsabeck noted that he believed several thousand died which may have been due to the Koi Herpes Virus (KHV). If this occurred, the virus may have been the result of floodwater and common carp introductions from the Illinois River.

Additional Research

We examined Reelfoot Lake near Samburg, Tennessee which is similar to the Emiquon Preserve in that they are both shallow backwater lakes, contain abundant aquatic vegetation and bird species, as well as, an abundance of diverse fish species including bowfin, gar species, largemouth bass, and common carp. Also, we are examining four southeastern Wisconsin lakes located near Mukwonago, Wisconsin which are similar to the Emiquon Preserve and Reelfoot Lake in that they contain abundant aquatic vegetation, bird species, and a diversity of fish species such as bowfin, largemouth bass, and common carp. Our data from Reelfoot Lake 2011-2013 and four southeastern Wisconsin lakes 2012 may suggest that they are functioning well with common carp due to high abundances of piscivores. However, we found no evidence of common carp predation in the piscivorous fish diets we examined. So, the native piscivorous fish species we examined may not influence common carp through direct predation but perhaps indirectly through other pathways. Additional research is needed to better understand what these pathways may be (Appendix C, D, E, F).

Also, while the Emiquon Preserve only experienced minor flooding impacts in 2013 (floodwater and fish species introductions), TNC's Merwin Preserve experienced major flooding impacts that blew a large hole in the south levee. We are now examining how both of these aquatic ecosystems respond to Illinois River introduction through pre-connection and post connection aquatic vegetation and fish community monitoring data collection. The knowledge gained will be essential for future management efforts including connection plans for both preserves, as well as future floodplain restoration projects.

Peer-Reviewed Publications

1. Michaels, Nerissa N., Greg G. Sass, Timothy W. Spier, and Mike Lemke. The biomanipulation of the largemouth bass *Micropterus salmoides* population to control invasive species and water clarity at The Nature Conservancy's Emiquon Preserve. *In Progress*.

Popular Publications

1. Emiquon Partnership. Experience Emiquon Brochure. Havana Printing Company. 2013. *Published*

Grants Funded

1. Greg G. Sass [1, 4], Bradley A. Ray [2], Todd D. VanMiddlesworth [1], Bryan Matthias [3], Rob Ahrens [3], Micheal S. Allen [3], and John Epifanio [1]. Modeling food web interactions and assessing feeding habits of bowfin, gar, and largemouth bass: a comparative study between The Nature Conservancy's Emiquon Preserve, Illinois and Reelfoot Lake, Tennessee. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. [3]University of Florida, Fisheries and Aquatic Sciences, Gainesville, Florida. [4] Wisconsin Department of Natural Resources, Madison, Wisconsin. June 2013. $8,172.

2. Greg G. Sass [1, 4], Bradley A. Ray [2], Todd D. VanMiddlesworth [1], Jack W. Grubaugh [3], and John D. Lyons [4]. Feeding habits of bowfin, gar, and largemouth bass: a comparative study between The Nature Conservancy's Emiquon Preserve, Illinois; Reelfoot Lake, Tennessee, and four southeastern Wisconsin lakes. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. [3] University of Tennessee at Martin, Department of Biological Sciences, Martin, Tennessee. [4] Wisconsin Department of Natural Resources, Madison, Wisconsin. January 2012. $6,350

3. Greg G. Sass [1], Bradley A. Ray [2], Todd D. VanMiddlesworth [1], and Jack W. Grubaugh [3]. Feeding habits of bowfin, gar, and largemouth bass: a comparative study between The Nature Conservancy's Emiquon Preserve, Illinois and Reelfoot Lake, Tennessee. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. [3] University of Tennessee at Martin, Department of Biological Sciences, Martin, Tennessee. June 2011. $1,905.

Data Presentations at Meetings and Abstracts

1. Andrew Casper, Heath Hagy, T.D. VanMiddlesworth, Nerissa Michaels, Christopher Hine, Aaron Yetter, Michelle Horath, Randolph Smith and Joshua Stafford. Vegetation response to restoration and management of Emiquon Preserve, 2007–2012. 5th Society For Ecological Restoration World Conference on Ecological Restoration, Madison, WI. 6-11 October 2013. Platform Presentation.

   No Abstract

2. T.D. VanMiddlesworth [1,2], Nerissa N. McClelland [3], and Andrew F. Casper [1]. Emiquon Fish community Response to 6 Years of Restoration. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. [3] Illinois Department of Natural Resources, Havana, Illinois. 5th Society For Ecological Restoration World Conference on Ecological Restoration, Madison, WI. 6-11 October 2013. Platform Presentation.

   No Abstract

3. T.D. VanMiddlesworth [1, 2], Greg G. Sass [3], Timothy W. Spier [2], and Bradley A. Ray [4]. Relative abundance and feeding habits of native piscivorous fishes at The Nature Conservancy's Emiquon Preserve and Reelfoot Lake: Can native fish control common carp? [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. [3] Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin. [4] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. 5th Society For Ecological Restoration World Conference on Ecological Restoration, Madison, WI. 6-11 October 2013. Poster Presentation.

   No abstract

4. T.D. VanMiddlesworth, Nerissa N. Michaels, Greg G. Sass, Bradley A. Ray, and Tim W. Spier. Is there a native recipe for controlling common carp? 143rd Annual Meeting of the American Fisheries Society, Little Rock, Arkansas. 8-12 September 2013. Platform Presentation.

   No Abstract

5. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier. The biomanipulation of the largemouth bass *Micropterus salmoides* population to control eutrophication and invasive species at The Nature Conservancy's Emiquon Preserve. 6th Annual Emiquon Science Symposium, Dickson Mounds Museum, Lewistown, IL. 8 March 2013. Poster Presentation.

No Abstract

6. T.D. VanMiddlesworth [1,2], Nerissa N. Michaels [1], and Andrew F. Casper [1]. The Nature Conservancy's Emiquon Preserve: Importance of aquatic restoration to nature and people. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. 6TH Annual Emiquon Science Symposium, Dickson Mounds Museum, Lewistown, IL. 8 March 2013. Platform Presentation.

Restoration of The Nature Conservancy's Emiquon Preserve has led to both ecological and societal benefits. The restored floodplain sustains a diverse (10 species) and abundant native submersed aquatic vegetation (SAV) community that is otherwise difficult to find within the Illinois River Valley today. As the diversity and plant density increased since restoration, so has the species richness and biomass of native fishes. The excellent quality of the Emiquon Preserve's SAV and fish communities provides excellent recreational opportunities to the public including fishing, hunting, and wildlife viewing, as well as new research questions for scientists. For example, 54% of the largemouth bass (*Micropterus salmoides*) population, 11% of the black crappie (*Pomoxis nigromaculatus*) population, and 14% of the bluegill (*Lepomis macrochirus*) population was considered to be at preferred, memorable, or trophy sizes in 2012. Another societal benefit is seen in the improved understanding of predator-prey interactions and potential invasive species control. Research on the diet analysis of piscivorous fish at the Emiquon Preserve, Tennessee's Reelfoot Lake, and four southeastern Wisconsin lakes may suggest that healthy piscivorous fish populations may contribute to the suppression of invasives like common carp (*Cyprinus carpio*). The ecological and societal opportunities that have emerged from restoration of the aquatic vegetation and fish communities at The Nature Conservancy's Emiquon Preserve will continually serve useful for future floodplain restoration efforts.

7. T.D. VanMiddlesworth [1,2], Greg G. Sass [3], Timothy W. Spier [2], and Bradley A. Ray [4]. Relative abundance and feeding habits of bowfin, spotted gar, and largemouth bass at The Nature Conservancy's Emiquon Preserve and Reelfoot Lake: Can native fish control common carp? [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. [3] Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin. [4] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. 6th Annual Emiquon Science Symposium, Dickson Mounds Museum, Lewistown, IL. 7 March 2013. Poster Presentation.

No Abstract

8. Nerissa N. Michaels and T.D. VanMiddlesworth. Aquatic vegetation monitoring at The Nature Conservancy's Emiquon Preserve, 2007-2011. 5th Annual Emiquon Science Symposium, Dickson Mounds Museum, Lewistown, IL. 8 March 2012. Platform Presentation.

The Illinois Natural History Survey's, Illinois River Biological Station has been conducting aquatic vegetation monitoring at The Nature Conservancy's Emiquon Preserve since the beginning of aquatic restoration in 2007. Aquatic vegetation monitoring is conducted in order to evaluate Key Ecological Attributes (KEA's) associated with restoration progress. There are three KEA's associated with the submersed aquatic vegetation (SAV) community, including underwater irradiance, hydrology, and community composition. Aquatic vegetation monitoring was conducted following the Long Term Resource Monitoring Program (LTRMP) aquatic vegetation sampling protocols. Ten native and 2 non-native SAV species have been observed growing in Thompson and Flag lakes since the beginning of restoration. Monitoring efforts have shown a significant increase in relative density of non-native Eurasian water milfoil *Myriophyllum spicatum* and a significant decrease in relative density of native species such as coontail *Ceratophyllum demersum*, American elodea *Elodea canadensis*, and leafy pondweed *Potamogeton foliosus* ($p<0.05$) from 2008-2011. Additionally, Secchi disc transparencies have significantly decreased since the beginning of restoration ($p<0.05$). Subsequently, the indicators for each KEA were within the desired range from 2008-2009, but were not within the desired range from 2010-2011.

9. T.D. VanMiddlesworth [1,2], Greg G. Sass [3], Timothy W. Spier [2], and Bradley A. Ray [4]. Relative abundance and feeding habits of bowfin, spotted gar, and largemouth bass at The Nature Conservancy's Emiquon Preserve and Reelfoot Lake: Can native fish species control invasive common carp? [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. [3] Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin. [4] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. Prairie Lightning Mini-Symposium, Urbana, IL. 20 September 2012. Poster Presentation.

No Abstract

10. T.D. VanMiddlesworth [1,2], Greg G. Sass [3], Timothy W. Spier [2], and Bradley A. Ray [4]. Relative abundance and feeding habits of bowfin, spotted gar, and largemouth bass at The Nature Conservancy's Emiquon Preserve and Reelfoot Lake: Can native fish species control invasive common carp? [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. [3] Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin. [4] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee.

142nd Annual Meeting of the American Fisheries Society, St. Paul, MN. 19-24 August 2012. Poster Presentation.

No abstract

11. T.D. VanMiddlesworth [1,2], Greg G. Sass [3], Timothy W. Spier [2], and Bradley A. Ray [4]. Relative abundance and feeding habits of bowfin, spotted gar, and largemouth bass at The Nature Conservancy's Emiquon Preserve and Reelfoot Lake: Can native fish species control invasive common carp? [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. [3] Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin. [4] University of Tennessee at Martin, Department of Agriculture, Geosciences, and Natural Resources, Martin, Tennessee. 44th Annual Meeting of the Mississippi River Research Consortium. Lacrosse, WI. 26-27 April 2012. Platform Presentation.

In 2011, we sampled Reelfoot Lake to better understand why this aquatic ecosystem has not become dominated by invasive common carp *Cyprinus carpio*. Reelfoot Lake is similar to the Emiquon Preserve in that they are both shallow, disconnected floodplain lakes which contain bowfin *Amia calva*, spotted gar *Lepisosteus oculatus*, largemouth bass *Micropterus salmoides*, and common carp. However, these lakes differ in that Reelfoot Lake is over 100 years old, while the Emiquon Preserve is only 5 years old. We used standardized pulsed-DC electrofishing at random and fixed sites to assess the fish communities and the diet contents of bowfin, spotted gar, and largemouth bass in both lakes. Our catch-per-unit effort data suggests that largemouth bass relative abundance at Reelfoot Lake was 23.6 fish/hr, but was 26.5 fish/hr at the Emiquon Preserve. Bowfin (6.7 fish/hr) and spotted gar (6.9 fish/hr) relative abundances at Reelfoot Lake were higher than bowfin (0.5 fish/hr) and spotted gar (0.3 fish/hr) relative abundances at the Emiquon Preserve. The relative abundance of the invasive common carp (6.8 fish/hr) was approximate to those of bowfin and spotted gar at Reelfoot Lake, whereas the relative abundance of common carp (2.4 fish/hr) was greater than those of bowfin and spotted gar at the Emiquon Preserve and is increasingly rapidly. Our bowfin, spotted gar, and largemouth bass diet analyses suggest they may not be selecting for young-of year common carp as a prey type. So these species might not be directly influencing common carp via predation but perhaps indirectly through other paths.

12. T.D. VanMiddlesworth [1,2], Nerissa N. Michaels [1], Greg G. Sass [1], and Timothy W. Spier [2]. The Fishes of Thompson Lake. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. Science Lecture Series, Dickson Mounds Museum, Lewistown, IL. 11 March 2012. Platform Presentation.

No Abstract

13. T.D. VanMiddlesworth [1,2], Nerissa N. Michaels [1], and Greg G. Sass [3]. The Nature Conservancy's Emiquon Preserve: Fish Community Monitoring, 2007-2011.
[1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois.
[2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois.
[3] Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin. 5[TH] Annual Emiquon Science Symposium, Dickson Mounds Museum, Lewistown, IL. 8 March 2012. Platform Presentation.

The Illinois Natural History Survey's, Illinois River Biological Station has been conducting fish community monitoring on Thompson Lake at The Nature Conservancy's Emiquon Preserve since 2007. Fish community monitoring is conducted to evaluate Key Ecological Attributes (KEA's) that were developed to determine restoration success including fish community assemblages and composition, spawning, nursery, over-wintering habitat, and feeding. We used a stratified-random sampling approach outlined by the Long Term Resource Monitoring Program's (LTRM) fish sampling protocols from 2007-2011. We collected a total of 1,290 fish in 2007, 32,907 fish in 2008, 9,860 fish in 2009, 11,957 fish in 2010, and 9,192 fish in 2011. Species richness has increased from 8 in 2007 to 17 in 2011. Native fishes remained dominant in our collections. However, invasive common carp *Cyprinus carpio* total catch has increased over time. In addition to fish community monitoring, stomach contents were collected from largemouth bass *Micropterus salmoides*, bowfin *Amia calva*, and spotted gar *Lepisosteus oculatus* at the Emiquon Preserve and a similarly disconnected floodplain lake of the Mississippi River, Reelfoot Lake, primarily using non-lethal gastric lavage to test for prey selection and young-of-year common carp predation in 2011. The information gained from fish monitoring and supplemental research may aid management efforts at the Emiquon Preserve and in future floodplain restoration efforts.

14. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier. The biomanipulation of the largemouth bass *Micropterus salmoides* population to control invasive species and eutrophication at The Nature Conservancy's Emiquon Preserve. 141st Annual Meeting of the American Fisheries Society, Seattle, WA, 4-8 Sept. 2011. Poster Presentation.

No Abstract

15. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier. The biomanipulation of the largemouth bass *Micropterus salmoides* population to control invasive species and eutrophication at The Nature Conservancy's Emiquon Preserve. 3rd Annual Meeting of the Midwest-Great Lakes Society for Ecological Restoration Chapter Meeting, Springfield, IL, 1-3 April 2011. Platform Presentation.

No Abstract

16. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier. The emerging food web in a newly restored floodplain lake: The Nature Conservancy's Emiquon Preserve. 49h

Annual Meeting of the Illinois Chapter of the American Fisheries Society, Peoria, IL, 2-4 March 2011. Platform Presentation.

No Abstract

17. T.D. VanMiddlesworth [1,2], Greg G. Sass [1], Timothy W. Spier [2], and Nerissa N. Michaels. Physiological refuges from predation based on dissolved oxygen concentrations at The Nature Conservancy's Emiquon Preserve. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. Western Illinois University, Biological Applications in GIS, BIOL 452 (G). 10 May 2011. Poster Presentation.

No Abstract

18. T.D. VanMiddlesworth [1,2], Greg G. Sass [1], Timothy W. Spier [2], Nerissa N. Michaels [1], Michael A. McClelland [1], Stephen M. Tyszko [1], and Thad R. Cook [1]. Aquatic vegetation and fish community monitoring at The Nature Conservancy's Emiquon Preserve: testing for regime shifts in ecosystem state. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. 43rd Annual Meeting of the Mississippi River Research Consortium. Lacrosse, WI. 28-29 April 2011. Poster Presentation.

No Abstract

19. T.D. VanMiddlesworth [1,2], Greg G. Sass [1], Timothy W. Spier [2], Nerissa N. Michaels [1], Michael A. McClelland [1], Stephen M. Tyszko [1], and Thad R. Cook [1]. Aquatic vegetation and fish community monitoring at The Nature Conservancy's Emiquon Preserve: testing for regime shifts in ecosystem state. [1] Illinois Natural History Survey, Illinois River Biological Station, Havana, Illinois. [2] Western Illinois University, Department of Biological Sciences, Macomb, Illinois. 3rd Annual Meeting of the Midwest-Great Lakes SER Chapter, University of Illinois Springfield, IL, 1-3 April 2011. Platform Presentation.

Thompson and Flag lakes of The Nature Conservancy's Emiquon Preserve comprise one of the larger floodplain restoration projects in the United States. From 2007-present, aquatic vegetation and fish community monitoring has been conducted using a multiple gear approach to evaluate a series of Key Ecological Attributes (KEA) relevant to restoration success. During 2007-2010 monitoring, native aquatic vegetation and fish species remained dominant. However, important monitoring trends in water clarity, invasive aquatic vegetation species including Eurasian Water Milfoil *Myriophyllum spicatum* and Curlyleaf Pondweed *Potamogeton crispus*, undesirable Gizzard Shad *Dorosoma cepedianum*, and invasive Common Carp *Cyprinus carpio* and Goldfish *Carassius auratus* have been detected. These trends may foreshadow a regime shift in ecosystem state from a clear-to turbid-water state. Therefore, the goals of my graduate research include: 1) testing for prey selection by

Largemouth Bass *Micropterus salmoides,* Bowfin *Amia calva,* and Gar species based on available prey fishes (e.g. Common Carp, Gizzard Shad, and every other fish species); 2) conducting laboratory studies with native fish species and Common Carp to test for physiological refuges from predation based on dissolved oxygen concentrations; 3) using otolith microchemistry to test for the origins of Common Carp at the Emiquon Preserve; and 4) testing trends in Common Carp, Largemouth Bass, Bowfin, waterfowl species diversity and use, submersed aquatic vegetation, and water quality to predict regime shifts.

20. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier. The emerging food web in a newly restored floodplain lake: The Nature Conservancy's Emiquon Preserve. 140th Annual Meeting of the American Fisheries Society, Pittsburgh, PA, 13-16 Sept. 2010. Platform Presentation.

No Abstract

21. Nerissa N. Michaels, Greg G. Sass, and Timothy W. Spier. The Nature Conservancy's Emiquon Preserve: the emerging food web in a newly restored floodplain lake. 42nd Annual Meeting of the Mississippi River Research Consortium. Lacrosse, WI. 22-23 April 2010. Platform Presentation.

No Abstract

22. Nerissa N. Michaels, Greg G. Sass, and Timothy W. Spier. The Nature Conservancy's Emiquon Preserve: the emerging food web in a newly restored floodplain lake. Graduate Student Research Symposium, WIU, Macomb, IL. 9 April 2010. Platform Presentation.

No Abstract

23. Nerissa N. Michaels, Greg G. Sass, and Timothy W. Spier. The Nature Conservancy's Emiquon Preserve: the emerging food web in a newly restored floodplain lake. 3rd Annual Emiquon Science Symposium, Dickson Mounds Museum, Lewistown, IL. 4 March 2010. Platform Presentation.

Two backwater lakes along the Illinois River, Thompson and Flag lakes, were historically known as two of the most productive backwater lakes of the Illinois River. In the early 1920's, Thompson and Flag lakes were leveed from the Illinois River, drained, and farmed. The area has recently been reclaimed by The Nature Conservancy. We collected stomach contents from largemouth bass *Micropterus salmoides* on a bi-weekly basis April – October, 2008 in order to determine the emerging food web at the Emiquon Preserve. A shift in diet contents from less profitable prey items (cladocerans, benthic invertebrates) to higher profitable prey items (fish) was observed in mid-July, 2008 as seen in community analysis and Index of Relative Importance (IRI) values for each prey group. Additionally, diet breadth (B) of largemouth bass significantly decreased over time ($p = 0.034$, $r^2 = 0.266$).

These observations may correspond to the fish management goal of maintaining bass at a hungry state at the appropriate time to inhibit the potential recruitment of invasive fish species in the early stages of the restoration process. Continued diet analysis will provide information regarding management implications for the fish community at Thompson Lake and for future floodplain lake restoration efforts.

24. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier, Kevin S. Irons, Michael A. McClelland, Timothy M. O'Hara, and Thad R. Cook. The Nature Conservancy's Emiquon Preserve: resetting and restoring Thompson Lake. 48th Annual Meeting of the Illinois Chapter of the American Fisheries Society Rend Lake Resort, IL. 24-25 February 2010. Poster Presentation

Thompson and Flag lakes, located in Fulton County, Illinois, were historically known as two of the most productive backwater lakes of the Illinois River. In the early 1920's, Thompson and Flag lakes were leveed from the Illinois River, drained, and farmed. Eighty years later the land was purchased by The Nature Conservancy with the intention to restore the lakes to their natural state; a fully functional floodplain labelled the Emiquon Preserve. The remnant agricultural farm ditches were drained, rotenoned, and later stocked with desirable fish species in spring 2007. The Illinois Natural History Survey's Illinois River Biological Station has conducted preliminary fish and aquatic vegetation monitoring on Thompson Lake since its restoration. We collected a total of 1,290 fish comprised of 8 species during the 2007 sampling period, and 32,907 fish comprised of 15 species in 2008. Aquatic vegetation sampling was limited in 2007 in order to reduce disturbance to the community during the first major year of growth, however aquatic vegetation sampling conducted in 2008 showed a community comprised of 14 species dominated by coontail *Ceratophyllum demersum.* Centrarchid diets were obtained using gastric lavage to determine the emerging food web and largemouth bass were Floy-tagged to determine growth rates, movement, and population size in 2008. The information gained from the fish and aquatic vegetation monitoring and supplemental research will help manage this system and provide future management recommendations for floodplain restoration efforts.

25. Nerissa N. Michaels, Greg G. Sass, Timothy M. O'Hara, Michael A. McClelland, Kevin S. Irons, and Thad R. Cook. The Nature Conservancy's Emiquon Preserve: fish and aquatic vegetation monitoring, 2007-2009. 70th Annual Midwest Fish and Wildlife Conference, Springfield, IL. 7-9 December 2009. Platform Presentation.

Thompson and Flag lakes were historically known as two of the most productive backwater lakes of the Illinois River. In the early 1920's, Thompson and Flag lakes were leveed from the Illinois River, drained, and farmed. Eighty years later the land was purchased by The Nature Conservancy with the intention to restore the lakes to their natural state. Rotenone was applied to remaining agricultural ditches in the Spring of 2007 in an attempt to rid the existing waters of invasive and nuisance fish species. The remnant farm ditches and the newly reformed Thompson Lake were then stocked with desirable fishes by the Illinois Department of Natural Resources in accordance with historical accounts of native fishes once present in the lakes. The Illinois Natural History Survey's Illinois River Biological Station has conducted fish and aquatic vegetation monitoring on Thompson Lake since its restoration in order to address Key Ecological Attributes (KEA's) developed for various plant and animal communities used to monitor restoration success. We used a stratified-random sampling approach outlined by the Long Term Resource Monitoring Program's fish and aquatic vegetation sampling protocols to quantitatively address these KEA's. Additionally, centrarchid diets were obtained using gastric lavage to determine the emerging food web, and largemouth bass *Micropterus salmoides* were Floy-tagged to determine growth rates, movement, and population size. The information gained from fish and aquatic vegetation monitoring and supplemental research will help manage this system and provide management recommendations for future floodplain restoration efforts.

26. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier, Kevin S. Irons, Michael A. McClelland, Timothy M. O'Hara, and Thad R. Cook. The Nature Conservancy's Emiquon Preserve: resetting and restoring Thompson Lake. 139th Annual Meeting of the American Fisheries Society, Nashville, TN. 30 Aug. – 3 Sept. 2009. Poster Presentation.

Thompson and Flag lakes, located in Fulton County, Illinois, were historically known as two of the most productive backwater lakes of the Illinois River. In the early 1920's, Thompson and Flag lakes were leveed from the Illinois River, drained, and farmed. Eighty years later the land was purchased by The Nature Conservancy with the intention to restore the lakes to their natural state; a fully functional floodplain labelled the Emiquon Preserve. Rotenone was applied to remaining agricultural ditches in the Spring of 2007 in an attempt to rid the existing waters of invasive and nuisance fish species. The remnant farm ditches and the newly reformed Thompson Lake were then stocked with desirable fishes by the Illinois Department of Natural Resources in accordance with historical accounts of native fishes once present in the lakes. The Illinois Natural History Survey's Illinois River Biological Station has conducted preliminary fish and aquatic vegetation monitoring on Thompson Lake since its restoration. We collected a total of 1,290 fish comprised of 8 species during the 2007 sampling period, and 32,907 fish comprised of 15 species in 2008. Largemouth bass *Micropterus salmoides* comprised 90% of the total catch with a mean of 376 bass/ hour electrofishing in 2007. In 2008, largemouth bass represented 3.1% of the total catch with a mean of 100 bass/hour electrofishing. One invasive species, an individual adult common carp *Cyprinus carpio*, was collected while electrofishing in 2007, while one invasive species, YOY and adult goldfish *Carassius auratus*, were collected while electrofishing and fyke netting in 2008. Unidentified Lepomis spp. (bluegill *L. macrochirus* or pumpkinseed *L. gibbosus* <40mm) dominated the total catch in 2008 comprising 76.5% of the total catch. Centrarchid diets were obtained using gastric lavage to determine the emerging food web, snorkeling surveys were conducted to determine habitat usage by fish species and size classes, and largemouth bass were Floy-tagged to determine growth rates, movement, and population size in 2008. Aquatic vegetation sampling was also conducted in 2008 and showed a community comprised of 14 species dominated by coontail *Ceratophyllum demersum.* The information gained from the fish and aquatic vegetation monitoring and supplemental research will help manage this system and provide future management recommendations for floodplain restoration efforts.

27. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier, Kevin S. Irons, Michael A. McClelland, Timothy M. O'Hara, and Thad R. Cook. The Nature Conservancy's Emiquon Preserve: resetting and restoring Thompson Lake. UIS Emiquon Field Station Public Lecture. 27 May 2009. Platform Presentation.

No Abstract

28. Nerissa N. Michaels, Greg G. Sass, Timothy W. Spier, Kevin S. Irons, Michael A. McClelland, Timothy M. O'Hara, and Thad R. Cook. The Nature Conservancy's Emiquon Preserve: resetting and restoring Thompson Lake. 41st Annual Meeting of the Mississippi River Research Consortium, Lacrosse, WI. 30 April – 1 May 2009. Platform Presentation.

Thompson and Flag lakes, located in Fulton County, Illinois, were historically known as two of the most productive backwater lakes of the Illinois River. In the early 1920's, Thompson and Flag lakes were leveed from the Illinois River, drained, and farmed. Eighty years later the land was purchased by The Nature Conservancy with the intention to restore the lakes to their natural state; a fully functional floodplain labeled the Emiquon Preserve. In the spring of 2007, rotenone was applied to remaining agricultural ditches in an attempt to rid the existing waters of invasive and nuisance fish species. The remnant farm ditches and the newly reformed Thompson Lake were then stocked with desirable fishes by the Illinois Department of Natural Resources in accordance with historical accounts of native fishes once present in the lakes. Thus far, 29 fish species have been stocked at the Emiquon Preserve. The Illinois Natural History Survey's Illinois River Biological Station has conducted preliminary fish and aquatic vegetation monitoring on Thompson Lake since its restoration. We used a multiple gear approach to sample the fish population in Thompson Lake from July-November, 2007, and April-October, 2008. We collected a total of 1,290 fish comprised of 8 species during the 2007 sampling period, and 32,907 fish comprised of 15 species in 2008. Largemouth bass *Micropterus salmoides* comprised 90% of the total catch with a mean of 376 bass/ hour electrofishing in 2007. In 2008, largemouth bass represented 3.1% of the total catch with a mean of 100 bass/hour electrofishing. One invasive species, an individual adult common carp *Cyprinus carpio,* was collected while electrofishing in 2007, while one invasive species, YOY and adult goldfish *Carassius auratus,* were collected while electrofishing and fyke netting in 2008 suggesting rotenone survival or unintentional stocking. Unidentified Lepomis spp. (bluegill *L. macrochirus* or pumpkinseed *L. gibbosus* <40mm) dominated the total catch in 2008 comprising 76.5% of the total catch. Centrarchid diets were obtained using gastric lavage to determine the emerging food web, snorkeling surveys were conducted to determine

habitat usage by fish species and size classes, and largemouth bass were Floy-tagged to determine growth rates, movement, and population size in 2008. Aquatic vegetation sampling was also conducted in 2008 and showed a community comprised of 14 species dominated by coontail *Ceratophyllum demersum.* The information gained from the fish and aquatic vegetation monitoring and supplemental research will help manage this system and provide future management recommendations for floodplain restoration efforts.

29. Nerissa N. Michaels, Greg G. Sass, Thad. R. Cook, T. Matt O'Hara, Kevin S. Irons, Michaels A. McClelland. The Nature Conservancy's Emiquon Preserve; fish and aquatic vegetation monitoring, 2007 – 2008. Emiquon Science Meeting, Dickson Mounds Museum, Lewistown, Illinois. 12 March 2009. Platform Presentation.

The Illinois Natural History Survey's, Illinois River Biological Station has been conducting preliminary fish and aquatic vegetation monitoring at The Nature Conservancy's, Emiquon Preserve in order to evaluate relevant Key Ecological Attributes (KEA's) that were developed to determine restoration success. We used a multiple gear approach to sample the fish community in Thompson Lake July-November, 2007, and April-October, 2008. We collected a total of 1,290 fish comprised of 8 species during the 2007 sampling period, and 32,907 fish comprising 15 species in 2008. Largemouth bass *Micropterus salmoides* represented 90% of the total catch in 2007 with a mean of 376 bass/hour electrofishing. Largemouth bass represented 3.1% of the total catch with a mean of 100 bass/hour electrofishing in 2008. Unidentified Lepomis spp. (bluegill *L. macrochirus* or pumpkinseed *L. gibbosus* <40mm) dominated the total catch in 2008 comprising 76.5% of the total catch. Additionally, centrarchid diets were obtained non-destructively using gastric lavage to determine the emerging food web, snorkeling surveys were conducted to determine habitat usage by fish species and size classes, and largemouth bass were Floy-tagged to determine growth rates, movement, and population size in 2008. Aquatic vegetation sampling was limited in 2007 to reduce interference during the first year of growth. Aquatic vegetation was monitored monthly April-October, 2008, and showed a community composition of 14 species dominated by coontail *Ceratophyllum demersum.* Overall, our KEA evaluation of fishes and aquatic vegetation suggests that the Emiquon Preserve restoration has been successful for these communities to date.

30. Nerissa N. Michaels. Predicting highly turbid zones as a limiting factor for aquatic vegetation growth using GIS and wind fetch at The Nature Conservancy's Emiquon Preserve. Western Illinois University, Biological Applications in GIS, BIOL 452 (G). 9 May 2008. Poster Presentation.

No Abstract

31. Nerissa N. Michaels and Greg G. Sass. Emiquon fish and vegetation sampling 2008. Emiquon Science Meeting, Dickson Mounds Museum, Lewistown, Illinois. 3 April 2008. Platform Presentation.

No Abstract

32. Nerissa N. Michaels, Greg G. Sass, Tim W. Spier, Thad R. Cook, T. Matt O'Hara, Kevin S. Irons, Michael A. McClelland, and Matt R. Stroub. The Nature Conservancy's Emiquon Preserve: resetting and restoring the Thompson Lake fish community. 40th Annual Meeting of the Mississippi River Research Consortium, Dubuque, Iowa. 24-25 April 2008. Poster Presentation.

Thompson and Flag lakes, located in Fulton County, Illinois, were historically known as two of the most productive backwater lakes of the Illinois River. In the early 1920's, Thompson and Flag lakes were leveed from the Illinois River, drained, and used for agricultural land. Eighty years later the land was purchased by The Nature Conservancy with plans to restore the lakes to their natural state: a fully functional floodplain labeled the Emiquon Preserve. In the spring of 2007, rotenone was applied in attempts to rid the existing waters of invasive and nuisance fish species. The remnant farm ditches and the newly reformed Thompson Lake were then stocked with desirable fishes by the Illinois Department of Natural Resources following historical accounts of native fishes once present in the lakes. Thus far, 24 fish species have been stocked at the Emiquon Preserve. The Illinois Natural History Survey's Illinois River Biological Station has conducted preliminary fish and aquatic vegetation monitoring on Thompson Lake since its restoration. We used a multiple gear approach to sample the fish population in Thompson Lake from July thru November, 2007. Aquatic vegetation sampling was limited to visual presence/absence and species observations to ensure low levels of disturbance during the first year of restoration. We also collected a total of 1,290 fish comprised of 8 species during this sampling period. Largemouth bass *Micropterus salmoides* contributed to 90% of the total catch with a mean of 376 bass/ hour electrofishing. One invasive species, an individual adult common carp *Cyprinus carpio*, was collected while electrofishing suggesting rotenone survival or unintentional stocking. Future sampling efforts will be intensified by implementing a stratified random sampling approach with supplemental fixed sites. Additional research will include snorkeling surveys to determine fish habitat usage and fish diet analyses to characterize the emerging food web. The information gained from the fish and aquatic vegetation monitoring and supplemental research will help manage and provide future management alternatives regarding restoration efforts.

33. Greg G. Sass, Kevin S. Irons, Matt T. O'Hara, Thad R. Cook, Michael A. McClelland, Nerissa N. Michaels, Melissa L. Smith, and Matt R. Stroub. Active versus passive management of common and grass carp for backwater lake native fish restoration: a case study from the Nature Conservancy's Emiquon Preserve. 39th Annual meeting of the Mississippi River Research Consortium, La Crosse, WI. 12-13 April 2007. Platform Presentation.

Non-native common (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) have been implicated for preventing the establishment of submersed aquatic vegetation and for negatively influencing the sustainability of native fish communities in backwater lake restoration efforts. The Nature Conservancy's Emiquon Preserve, a >2,833 hectare backwater lake restoration effort on the Illinois River, is faced with the dilemma of actively managing for common and grass carp with rotenone or allowing native/exotic species interactions to determine the success of the restoration effort. We sampled the fish populations of the Emiquon Preserve in 2001, and more recently in the winter of 2006. In 2001, common and grass carp comprised 20% of the fish sampled and represented 2 of the 5 fish species encountered. However, in 2006, we observed a fish community dominated by native Illinois River backwater fishes. Common carp comprised only 9% of the fish sampled and no grass carp were captured. Data from the Long Term Resource Monitoring Program suggests that the native fish species assemblage of the Emiquon Preserve is not reflective of the current mainstem Illinois River fishery. Therefore, the Nature Conservancy is faced with the trade-off of: 1) actively removing all fish from the preserve in order to establish an augmented native fish community; or 2) passively allowing the native and unique fish community to remain with carp present. Evidence from the Nature Conservancy's Spunky Bottoms Preserve suggests that passive management of carp may be achievable given certain native fish species assemblages and water level management.

34. Greg G. Sass, Kevin S. Irons, Matt T. O'Hara, Thad R. Cook, Michael A. McClelland, Nerissa N. Michaels, Melissa L. Smith, and Matt R. Stroub. Active versus passive management of common and grass carp for backwater lake native fish restoration: a case study from the Nature Conservancy's Emiquon Preserve. 45th Annual meeting of the Illinois Chapter of the American Fisheries Society, Shelbyville, IL. 27-28 February 2007. Platform Presentation.

Non-native common (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) have been implicated for preventing the establishment of submersed aquatic vegetation and for negatively influencing the sustainability of native fish communities in backwater lake restoration efforts. The Nature Conservancy's Emiquon Preserve, a >2,833 hectare backwater lake restoration effort on the Illinois River, is faced with the dilemma of actively managing for common and grass carp with rotenone or allowing native/exotic species interactions to determine the success of the restoration effort. We sampled the fish populations of the Emiquon Preserve in 2001, and more recently in the winter of 2006. In 2001, common and grass carp comprised 20% of the fish sampled and represented 2 of the 5 fish species encountered. However, in 2006, we observed a fish community dominated by native Illinois River backwater fishes. Common carp comprised only 9% of the fish sampled and no grass carp were captured. Data from the Long Term Resource Monitoring Program suggests that the native fish species assemblage of the Emiquon Preserve is not reflective of the current mainstem Illinois River fishery. Therefore, the Nature Conservancy is faced with the trade-off of: 1) actively removing all fish from the preserve in order to establish an augmented native fish community; or 2) passively allowing the native and unique fish community to remain with carp present. Evidence from the Nature Conservancy's Spunky Bottoms Preserve suggests that passive management of carp may be

achievable given certain native fish species assemblages and water level management.

Outreach, Inter- and Intra-agency Collaboration

1. Conducted electrofishing demonstration on TNC's Emiquon Preserve for TNC's LEAF Interns. 10 July 2013.

2. Conducted electrofishing demonstration and presentation on TNC's Emiquon Preserve for Spoon River College professor and ecology students. 10 July 2013.

3. Taught TNC interns about Emiquon fish and aquatic vegetation monitoring while they assisted with the field work. June-July 2013.

4. Discussed and transferred Emiquon aquatic vegetation data to UIS graduate student. 30 May 30 2013.

5. Conducted a fish session at the Emiquon Conservation Academy for high school students with UIS professor Dr. Keenan Dungey. 22 September 2012.

6. Taught Dickson Mounds Museum employee about Emiquon fish and aquatic vegetation monitoring while they assisted with the field work. 11 September 2012.

7. Assisted with lakeside setup at the Emiquon Complex Ramsar dedication ceremony. 8 August 2012.

8. Conducted electrofishing demonstration and presentation on TNC's Emiquon Preserve for Spoon River College professor and ecology students. 18 July 2012.

9. Taught TNC interns about Emiquon fish and aquatic vegetation monitoring while they assisted with the field work. June and July 2012.

10. Conducted an Emiquon master naturalist course with UIS graduate student. 5 October 2011.

11. Taught members from the Americorps about Emiquon fish and aquatic vegetation monitoring while they assisted with the field work. September and October 2011.

12. Conducted a fish diet analysis and Emiquon research discussion lab for Springfield, IL Eagle Scouts. 20 July 2011.

13. Assisted Dr. Richard Sparks intern with Emiquon aquatic vegetation field sampling and research. 21-23 June 2011.

14. Assisted with Emiquon Preserve informational booth at the Emiquon grand opening. 4 June 2011.

15. Conducted electrofishing demonstration and presentation on TNC's Emiquon Preserve for Pontiac, IL gifted school students. 13 May 2011.

16. Conducted electrofishing demonstration and presentation on TNC’s Emiquon Preserve for RHS high school students. 12 May 2011.

17. Attended and proposed graduate research goals at the Emiquon Science Workshop at Dickson Mounds Museum, Lewistown, IL. 28 January 2011.

18. Conducted electrofishing demonstration and presentation on TNC’s Emiquon Preserve for RHS high school students. 12 May 2010.

19. Conducted Emiquon Preserve tour for WIU graduate students and professor Dr. Tim Spier. 15 April 2010.

20. Conducted Thompson Lake History booth at Fulton County Soil and Water Conservation District “Conservation Days” in Lewistown, IL. 23 September 2009.

21. Conducted field demonstrations and informational presentations to voyager canoe riders from the electrofishing boat on Thompson Lake for The Nature Conservancy’s 2009 Lakefest. 29 August 2009.

22. Conducted Illinois Natural History Survey, Illinois River Biological Station booth at the INHS 150th anniversary celebration providing information on aquatic ecology including information regarding The Nature Conservancy’s Emiquon Preserve. Champaign, IL. 27 September 2008.

23. Nerissa N. Michaels. The Nature Conservancy’s Emiquon Preserve. Central Christian Church Fish Fry, Havana, IL. 18 August 2008. Presentation.

24. Assisted photographers Brian Skerry and Mauricio Handler with a tour of Thompson Lake and aquatic research at the The Nature Conservancy’s Emiquon Preserve. 28-31 July 2008.

Technical Reports

1. T.D. VanMiddlesworth, Nerissa N. Michaels, and Andrew F. Casper. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring 6-year (2007-2012) Report. INHS Technical Report 2014 (01).

2. T.D. VanMiddlesworth, Nerissa N. Michaels, and Andrew F. Casper. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring Annual Report. INHS Technical Report 2013 (02).

3. T.D. VanMiddlesworth, Nerissa N. Michaels, Greg G. Sass. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring Annual Report. INHS Technical Report 2012 (01).

4. T.D. VanMiddlesworth, Nerissa N. Michaels, Greg G. Sass. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring Annual Report. INHS Technical Report 2011 (06).

5. Nerissa Michaels and Greg Sass. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring Annual Report. INHS Technical Report 2010 (14).

6. Nerissa Michaels and Greg Sass. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring Annual Report. INHS Technical Report 2009 (10).

7. Nerissa Michaels and Greg Sass. The Nature Conservancy's Emiquon Preserve Fish and Aquatic Vegetation Monitoring Annual Report. INHS Technical Report 2008 (56).

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Havera, Stephen P., and Lynn L. Anderson. 2003. The Thompson Lake/Emiquon Story. Illinois Natural History Survey. Print.

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Simon, T.P., and R. Wallus. 2004. Reproductive Biology and Early Life History of Fishes in the Ohio River Drainage: Catfish and Madtoms. Boca Raton, FL: CRC.

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Yin, Y., J.S. Winkelman, and H.A. Langrehr. 2000. Long Term Resource Monitoring Program Procedures: Aquatic Vegetation Monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI.

Table 1. Aquatic vegetation and fish sampling dates at Thompson and Flag lakes in 2013.

Month	Aquatic Vegetation Sampling Dates	Fish Sampling Dates
April		4/15/2013-4/16/2013
May	5/16/2013-5/17/2013	5/22/2013-5/24/2013
June	6/18/2013-6/19/2013	6/20/2013, 6/27/2013-6/28/2013
July	7/12/2013, 7/15/2013-7/16/2013	7/23/2013-7/24/2013, 7/29/2013
August	8/14/2013-8/16/2013	8/21/2013-8/22/2013, 8/29/2013
September	9/11/2013-9/12/2013	9/17/2013-9/18/2013, 9/19/2013
October		10/21/2013-10/22/2013, 10/25/2013

Table 2. Total number of vegetated and un-vegetated random aquatic vegetation sampling sites at Thompson/Flag lakes in 2013.

	North/Middle/South
Vegetated	167
Un-vegetated	43
Total	210

Table 3. Aquatic plant species observed and/or collected and percent composition of vegetated random sites at Thompson/Flag lakes in 2013; * represents non-native species.

	Common name	Scientific Name	Family	%
	American pondweed	*Potamogeton nodosus*	Potamogetonaceae	31.9
*	Eurasian watermilfoil	*Myriophyllum spicatum*	Haloragaceae	15.6
	sago pondweed	*P. pectinatus*	Potamogetonaceae	13.9
	southern naiad	*Najas guadalupensis*	Najadaceae	13.6
	coontail	*Ceratophyllum demersum*	Ceratophyllaceae	11.7
	leafy pondweed	*P. foliosus*	Potamogetonaceae	4.8
	brittle naiad	*N. minor*	Najadaceae	3.5
	narrow-leaved cattail	*Typha angustifolia*	Typhaceae	1.8
	American elodea	*Elodea canadensis*	Hydrocharitaceae	0.9
	Lemnaceae	*Lemna spp.*	Lemnaceae	0.8
	Characeae	*Chara spp.*	Characeae	0.5
	creeping water primrose	*Ludwigia peploides*	Onagraceae	0.3
	American lotus	*Nelumbo lutea*	Nelumbonaceae	0.3
*	curly-leaf pondweed	*P. crispus*	Potamogetonaceae	0.2
	Illinois pondweed	*P. Illinoensis*	Potamogetonaceae	0.2

Total Species	**15**
Total Families	**10**

Table 4. Fish species list showing total catch and percent composition of total catch for each species collected at Thompson Lake in 2013; * represents non-native species.

	Common name	Scientific name	Family	No.	%
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	7442	48.0
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	2894	18.7
	unidentified *Lepomis* spp.	*Lepomis* spp.	Centrarchidae	2128	13.7
	bluegill	*Lepomis macrochirus*	Centrarchidae	1658	10.7
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	473	3.1
	largemouth bass	*Micropterus salmoides*	Centrarchidae	450	2.9
	pumpkinseed	*L. gibbosus*	Centrarchidae	129	0.8
*	common carp	*Cyprinus carpio*	Cyprinidae	92	0.6
	bowfin	*Amia calva*	Amiidae	59	0.4
	unidentified *Ameiurus* spp.	*Ameiurus* spp.	Ictaluridae	41	0.3
	white crappie	*P. annularis*	Centrarchidae	36	0.2
	black bullhead	*Ameiurus melas*	Ictaluridae	20	0.1
	shortnose gar	*Lepisosteus platostomus*	Lepisostidae	18	0.1
	starhead topminnow	*Fundulus dispar*	Fundulidae	16	0.1
	spotted gar	*L. oculatus*	Lepisostidae	14	0.1
	yellow bullhead	*A. natalis*	Ictaluridae	7	0.0
	unidentified Catostomidae spp.	*Ictiobus* spp.	Catostomidae	3	0.0
	warmouth	*L. gulosus*	Centrarchidae	3	0.0
	brown bullhead	*A. nebulosus*	Ictaluridae	2	0.0
	emerald shiner	*Notropis atherinoides*	Cyprinidae	1	0.0
	mud darter	*Etheostoma asprigene*	Percidae	1	0.0
	sauger	*Stizostedion canadense*	Percidae	1	0.0
	bluegill x pumpkinseed	*L. macrochirus x L. gibbosus*	Centrarchidae	1	0.0

Total Fish	**15489**
Total Species	**19**
Total Families	**9**

Table 5. Percent total catch and mean catch per unit effort (CPUE) of each fish species collected while electrofishing at Thompson Lake in 2013; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	7307	87.5	1218
	largemouth bass	*Micropterus salmoides*	Centrarchidae	367	4.4	61
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	295	3.5	49
	unidentified *Lepomis* spp.	*Lepomis* spp.	Centrarchidae	181	2.2	30
	bluegill	*Lepomis macrochirus*	Centrarchidae	103	1.2	17
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	54	0.6	9
*	common carp	*Cyprinus carpio*	Cyprinidae	18	0.2	3
	bowfin	*Amia calva*	Amiidae	10	0.1	2
	spotted gar	*L. oculatus*	Lepisostidae	5	0.1	1
	white crappie	*P. annularis*	Centrarchidae	3	0.0	1
	pumpkinseed	*L. gibbosus*	Centrarchidae	2	0.0	<1
	starhead topminnow	*Fundulus dispar*	Fundulidae	2	0.0	<1
	brown bullhead	*A. nebulosus*	Ictaluridae	1	0.0	<1
	shortnose gar	*Lepisosteus platostomus*	Lepisostidae	1	0.0	<1
	warmouth	*L. gulosus*	Centrarchidae	1	0.0	<1

Total Fish	**8350**
Total Species	**14**
Total Families	**7**

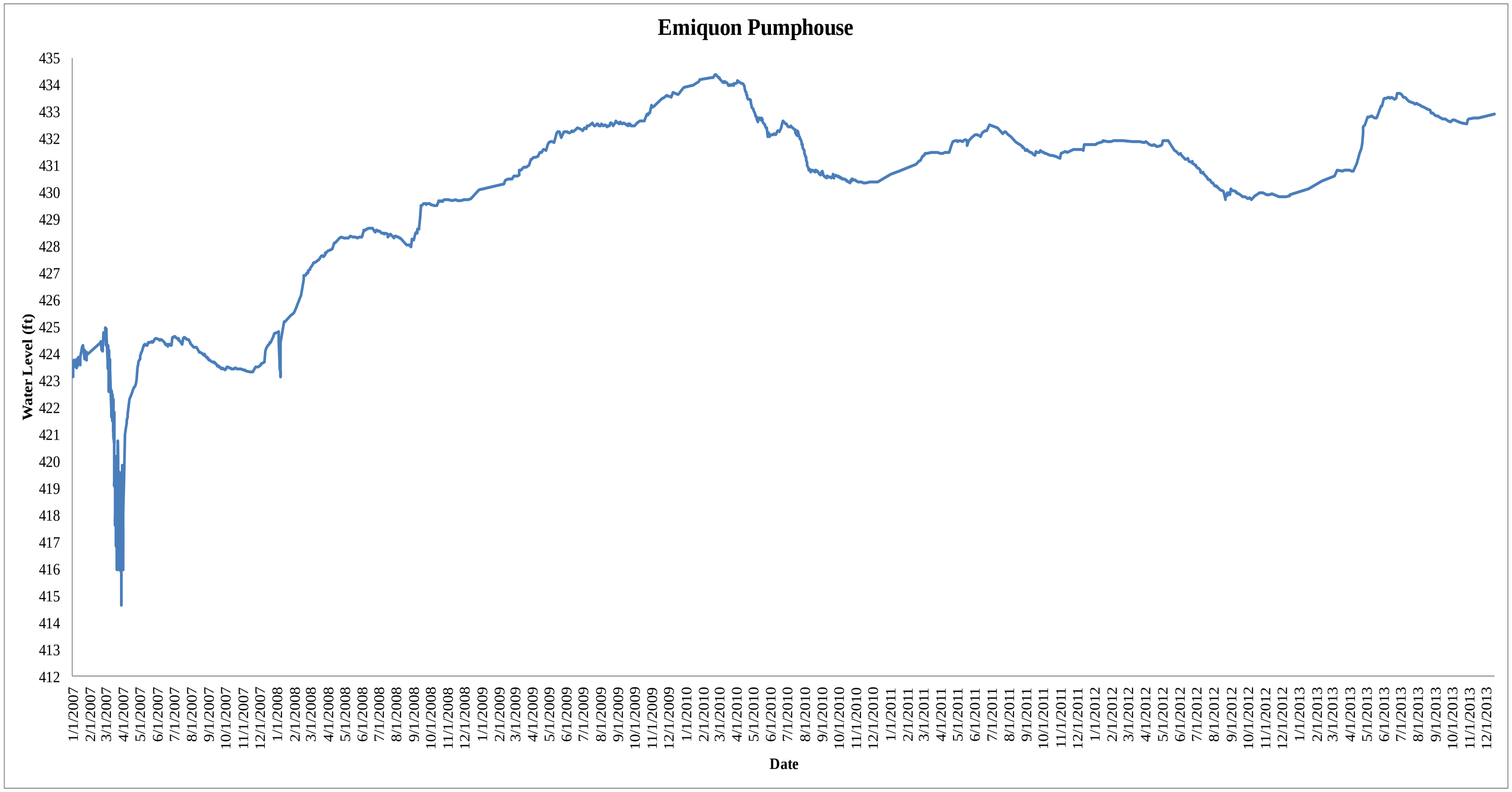
Table 6. Mean catch per unit effort (CPUE) for all fish species collected by all gears except electrofishing at Thompson Lake in 2013; * represents non-native species.

	Common name	Scientific name	Family	Fyke	Mini-Fyke	Tandem Fyke	Tandem Mini-Fyke
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	1	3	1	1
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	35	48	67	5
	unidentified *Lepomis* spp.	*Lepomis* spp.	Centrarchidae	<1	69		1
	bluegill	*Lepomis macrochirus*	Centrarchidae	24	23	29	6
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	2	4	<1	1
	largemouth bass	*Micropterus salmoides*	Centrarchidae	1	1	3	
	pumpkinseed	*L. gibbosus*	Centrarchidae	3	1	1	1
*	common carp	*Cyprinus carpio*	Cyprinidae	1	1.0	2	
	bowfin	*Amia calva*	Amiidae	2	<1	<1	
	unidentified *Ameiurus* spp.	*Ameiurus* spp.	Ictaluridae		1.0		1
	white crappie	*P. annularis*	Centrarchidae	1	<1	1	<1
	black bullhead	*Ameiurus melas*	Ictaluridae	<1	<1	1	
	shortnose gar	*Lepisosteus platostomus*	Lepisostidae	1	<1	<1	
	starhead topminnow	*Fundulus dispar*	Fundulidae		1		
	spotted gar	*L. oculatus*	Lepisostidae	<1	<1		
	yellow bullhead	*A. natalis*	Ictaluridae		<1	<1	<1
	unidentified Catostomidae spp.	*Ictiobus* spp.	Catostomidae		<1		
	warmouth	*L. gulosus*	Centrarchidae		<1		
	brown bullhead	*A. nebulosus*	Ictaluridae	<1			
	emerald shiner	*Notropis atherinoides*	Cyprinidae		<1		
	mud darter	*Etheostoma asprigene*	Percidae		<1		
	sauger	*Stizostedion canadense*	Percidae	<1			
	bluegill x pumpkinseed	*L. macrochirus x L. gibbosus*	Centrarchidae		<1		
	Total Fish			**1969**	**4321**	**741**	**108**
	Total Species			**15**	**17**	**12**	**7**
	Total Families			**7**	**9**	**6**	**4**

Table 7. Relative weight (Wr) during 2012-2013 and mean relative weight (Wr) during 2007-2012 for black crappie (*Pomoxis nigromaculatus*) $\geq$100 mm, bluegill (*Lepomis macrochirus*) $\geq$80 mm, pumpkinseed (*Lepomis gibbosus*) $\geq$80 mm, largemouth bass (*Micropterus salmoides*) $\geq$150 mm, and gizzard shad (*Dorosoma cepedianum*) $\geq$100 mm collected from Thompson Lake.

Common name	Scientific name	Mean Wr (2012)	Mean Wr (2013)	Mean Wr (2007-2012)
black crappie	*Pomoxis nigromaculatus*	105%	100%	109%
bluegill	*Lepomis macrochirus*	103%	99%	110%
pumpkinseed	*L. gibbosus*	103%	104%	97%
largemouth bass	*Micropterus salmoides*	95%	93%	100%
gizzard shad	*Dorosoma cepedianum*	90%	91%	96%

<u>Figure 1.</u> All Emiquon pumphouse water level (ft asl) gauge readings during January-December, 2007-2013.



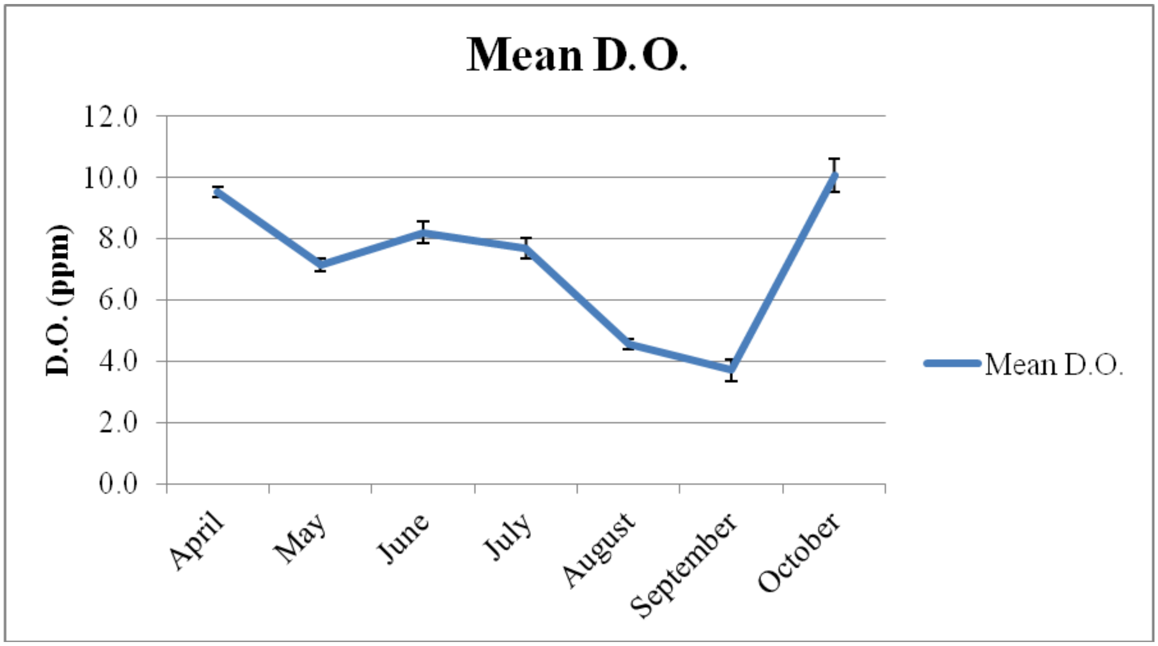


Figure 2. Monthly mean dissolved oxygen concentrations for all random aquatic vegetation and fish sampling sites at Thompson and Flag lakes in 2013. Error bars represent one standard error about the mean.

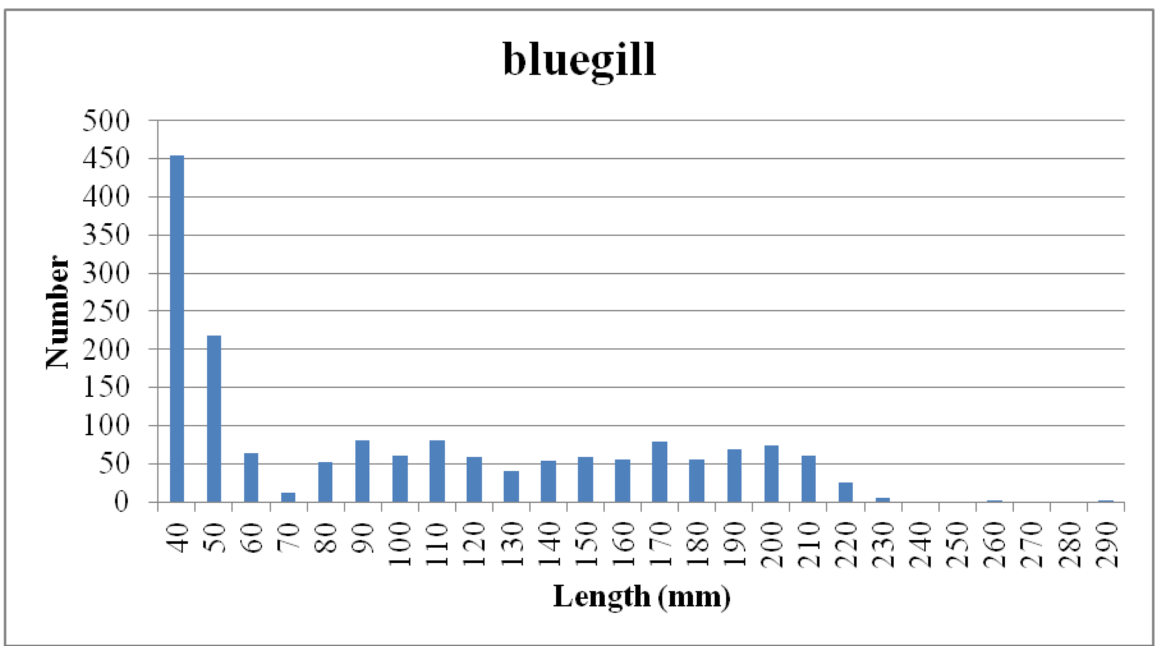


Figure 3. Length-frequency distribution for bluegill (*Lepomis macrochirus*) collected from Thompson Lake in 2013.

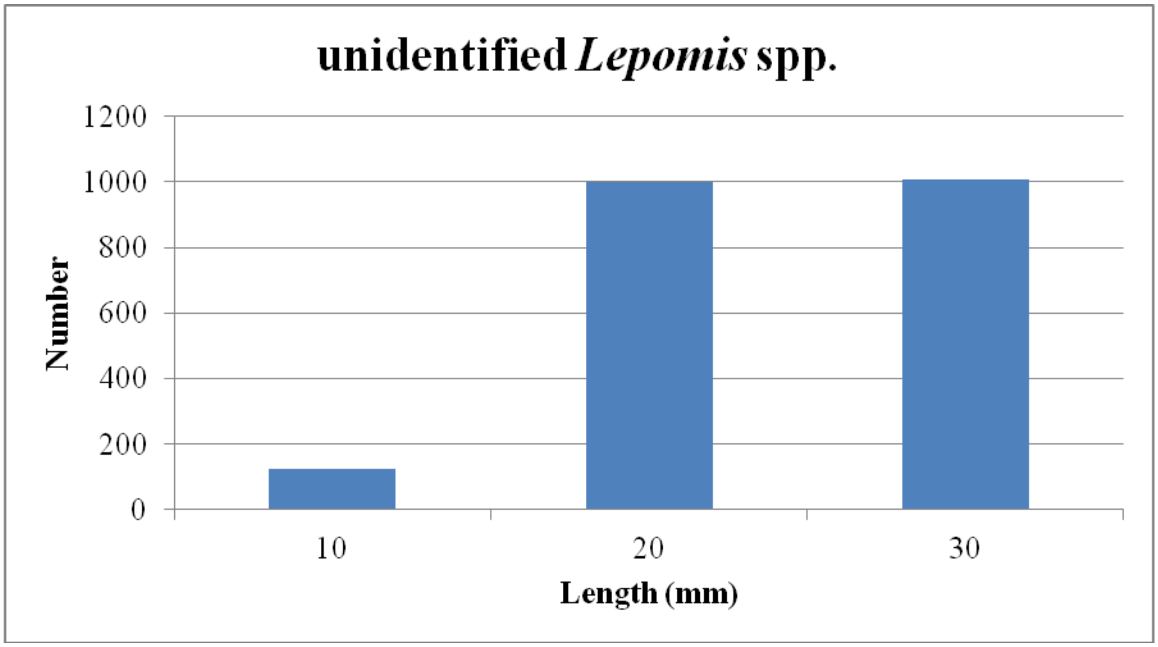


Figure 4. Length-frequency distribution for unidentified young-of-the-year (YOY) *Lepomis* spp. (bluegill or pumpkinseed with lengths <40mm) collected from Thompson Lake in 2013.

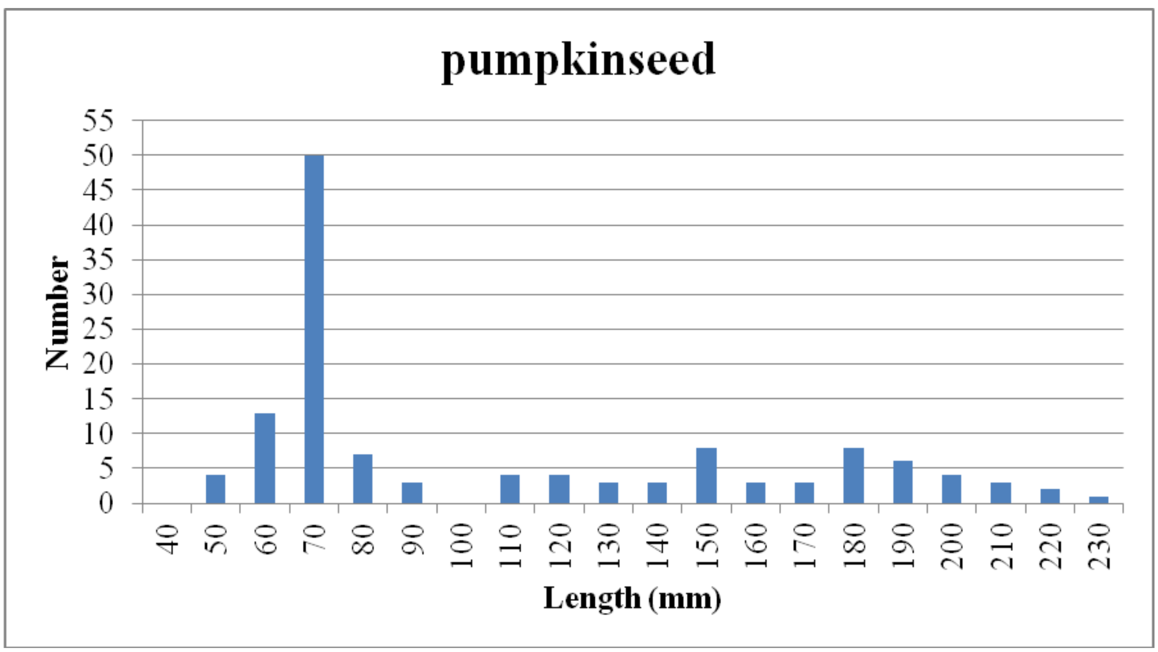


Figure 5. Length-frequency distribution for pumpkinseed (*Lepomis gibbosus*) collected from Thompson Lake in 2013.

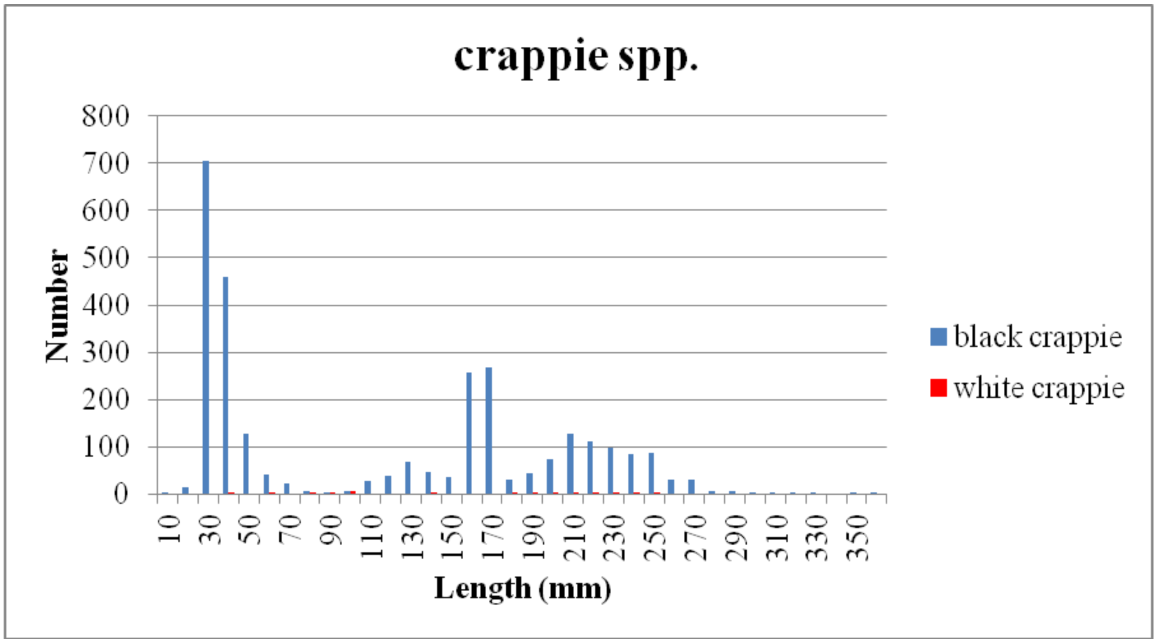


Figure 6. Length-frequency distribution for black crappie (*Pomoxis nigromaculatus*) and white crappie (*Pomoxis annularis*) collected from Thompson Lake in 2013.

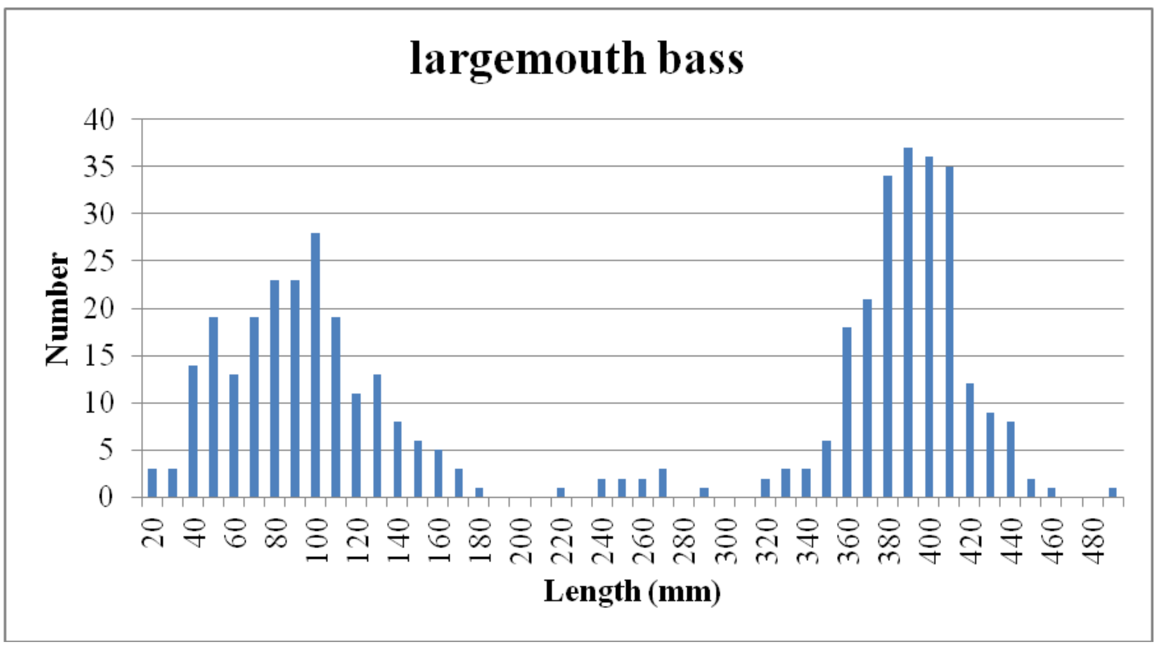


Figure 7. Length-frequency distribution for largemouth bass (*Micropterus salmoides*) collected from Thompson Lake in 2013.

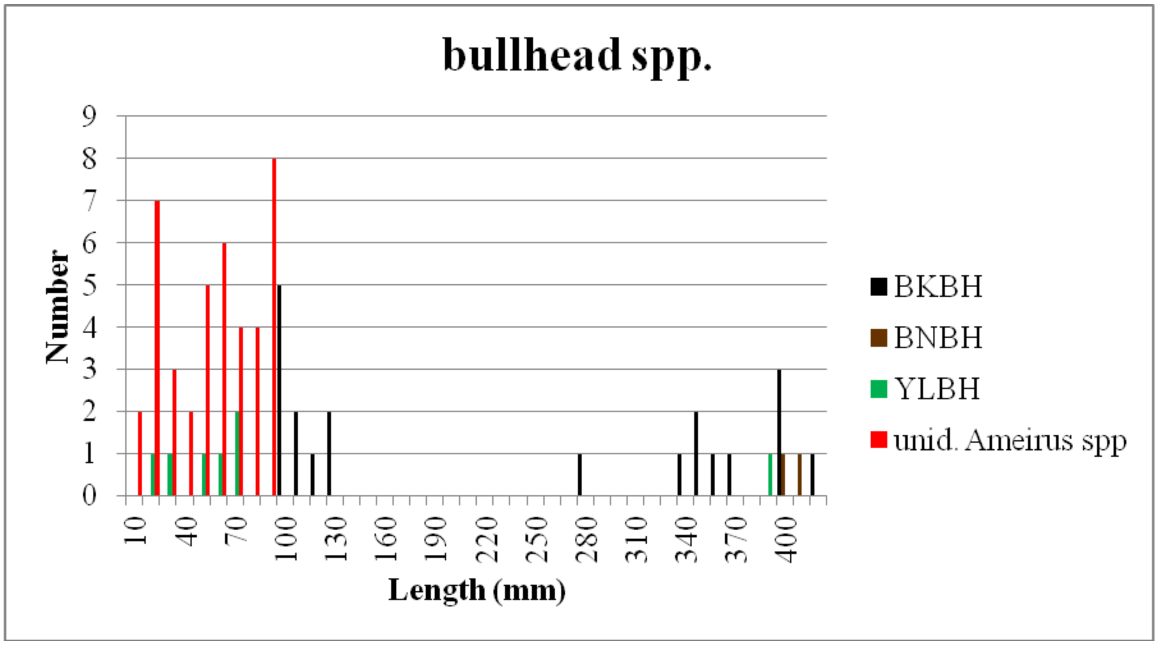


Figure 8. Length-frequency distribution for black bullhead (*Ameiurus melas*), brown bullhead (*A. nebulosus*), yellow bullhead (*A. natalis*) and unidentified *Ameiurus* spp. collected from Thompson Lake in 2013.

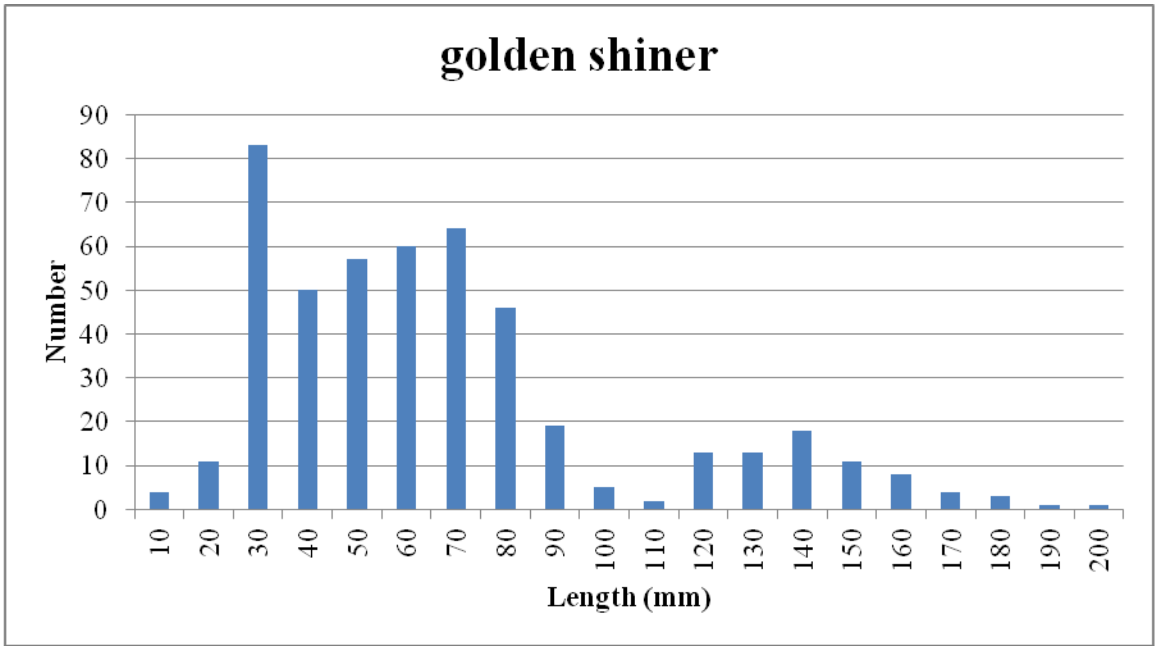


Figure 9. Length-frequency distribution for golden shiner *(Notemigonus crysoleucas)* collected from Thompson Lake in 2013.

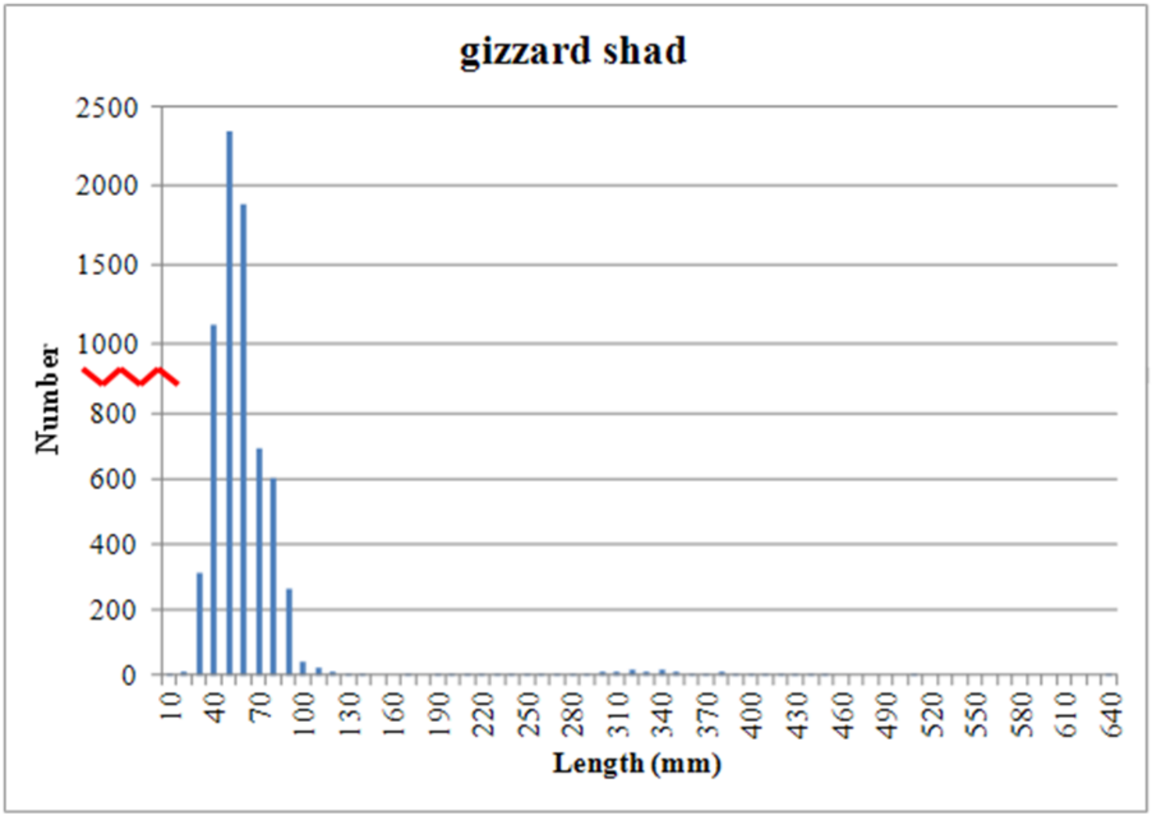


Figure 10. Length-frequency distribution for gizzard shad (*Dorosoma cepedianum*) collected from Thompson Lake in 2013.

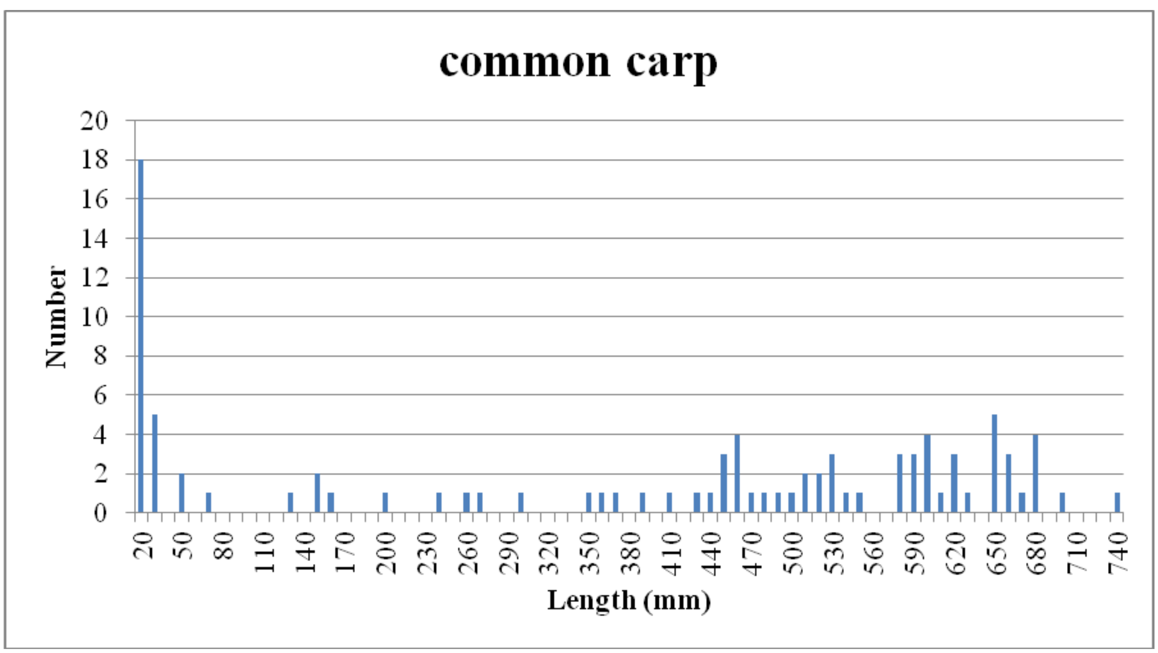


Figure 11. Length-frequency distribution for common carp (*Cyprinus carpio*) collected from Thompson Lake in 2013.

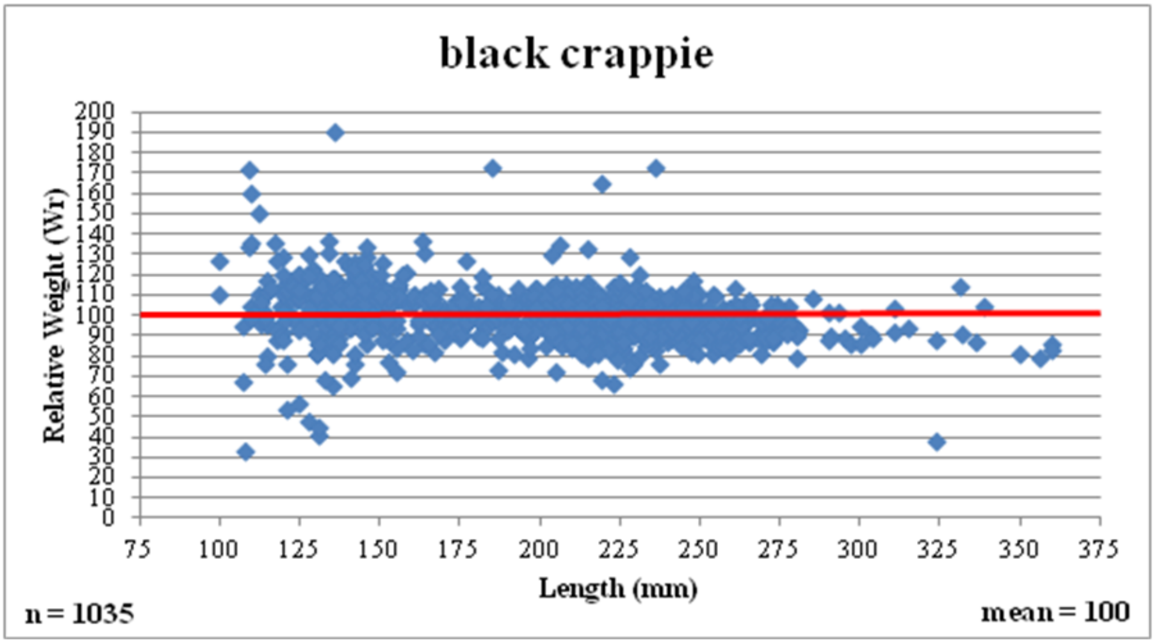


Figure 12. Relative weight (Wr) of black crappie (*Pomoxis nigromaculatus*) ≥100 mm collected from Thompson Lake in 2013. Red line represents 100% relative weight.

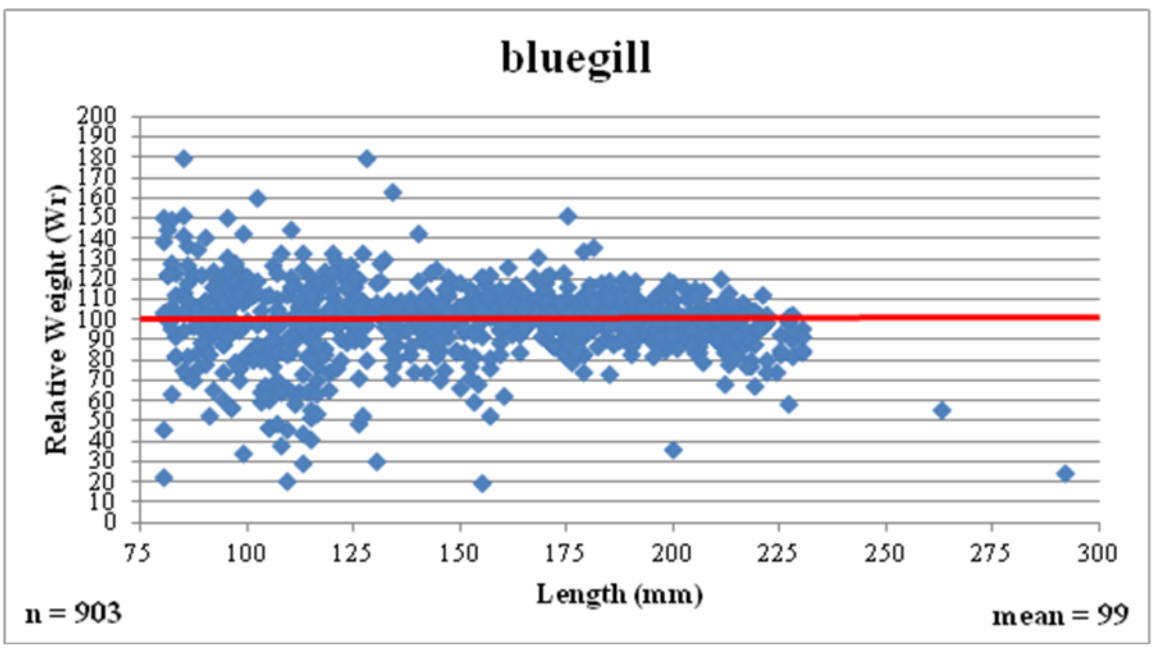
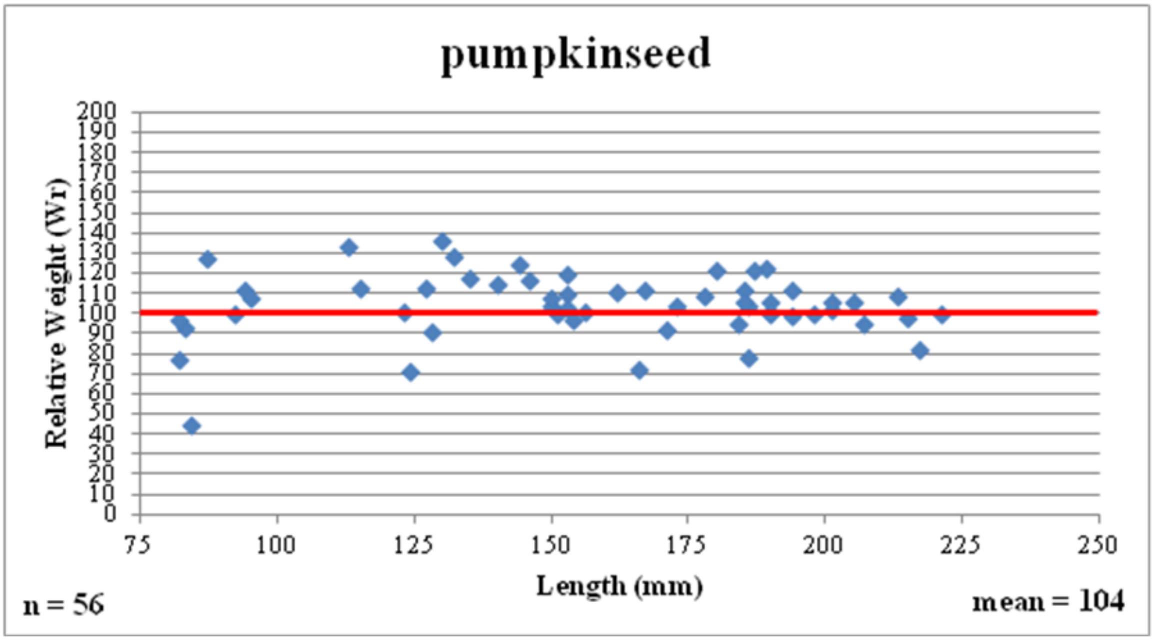
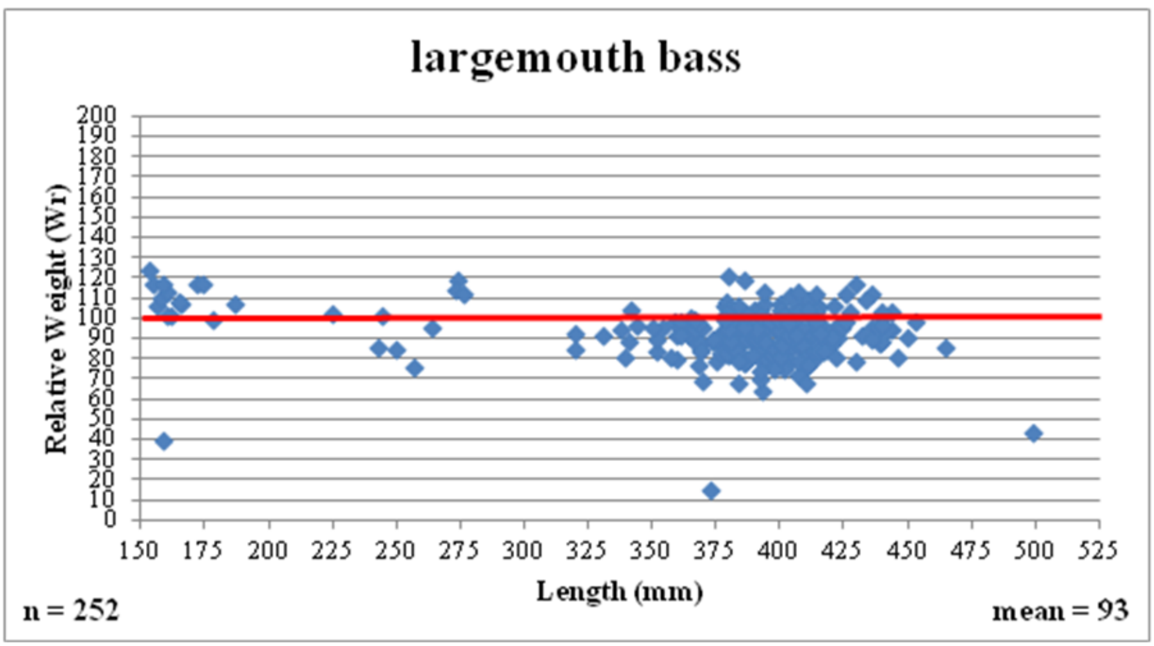


Figure 13. Relative weight (Wr) of bluegill (*Lepomis macrochirus*) ≥80 mm collected from Thompson Lake in 2013. Red line represents 100% relative weight.



<u>Figure 14</u>. Relative weight (Wr) of pumpkinseed (*Lepomis gibbosus*) ≥ 80 mm collected from Thompson Lake in 2012. Red line represents 100% relative weight.



<u>Figure 15</u>. Relative weight (Wr) of largemouth bass (*Micropterus salmoides*) ≥ 150 mm collected from Thompson Lake in 2013. Red line represents 100% relative weight.

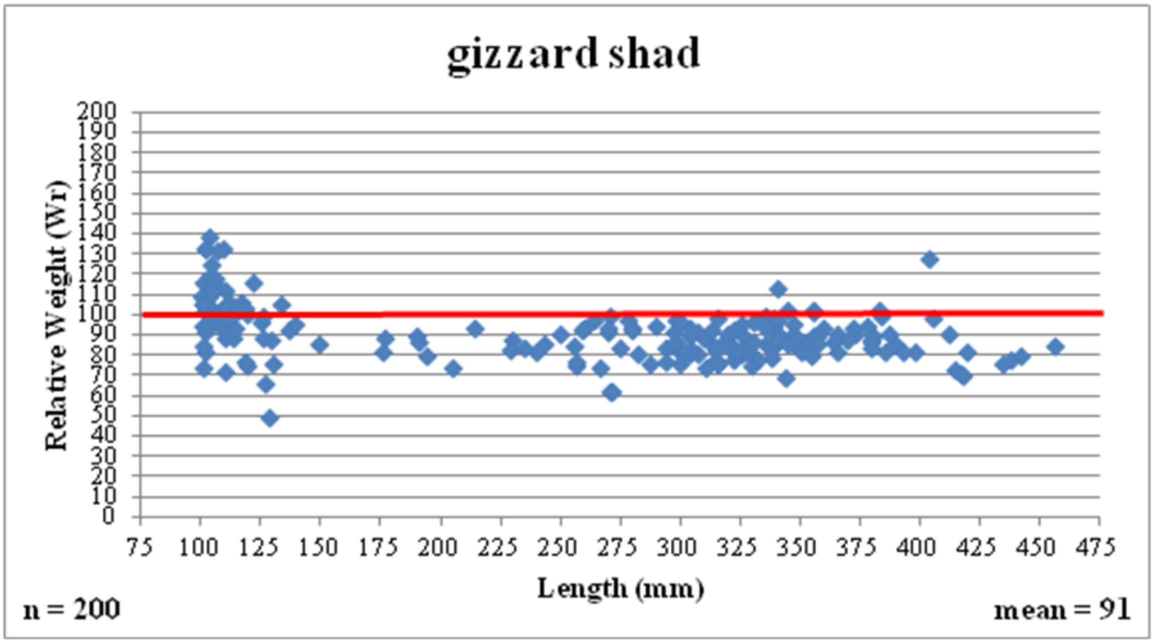
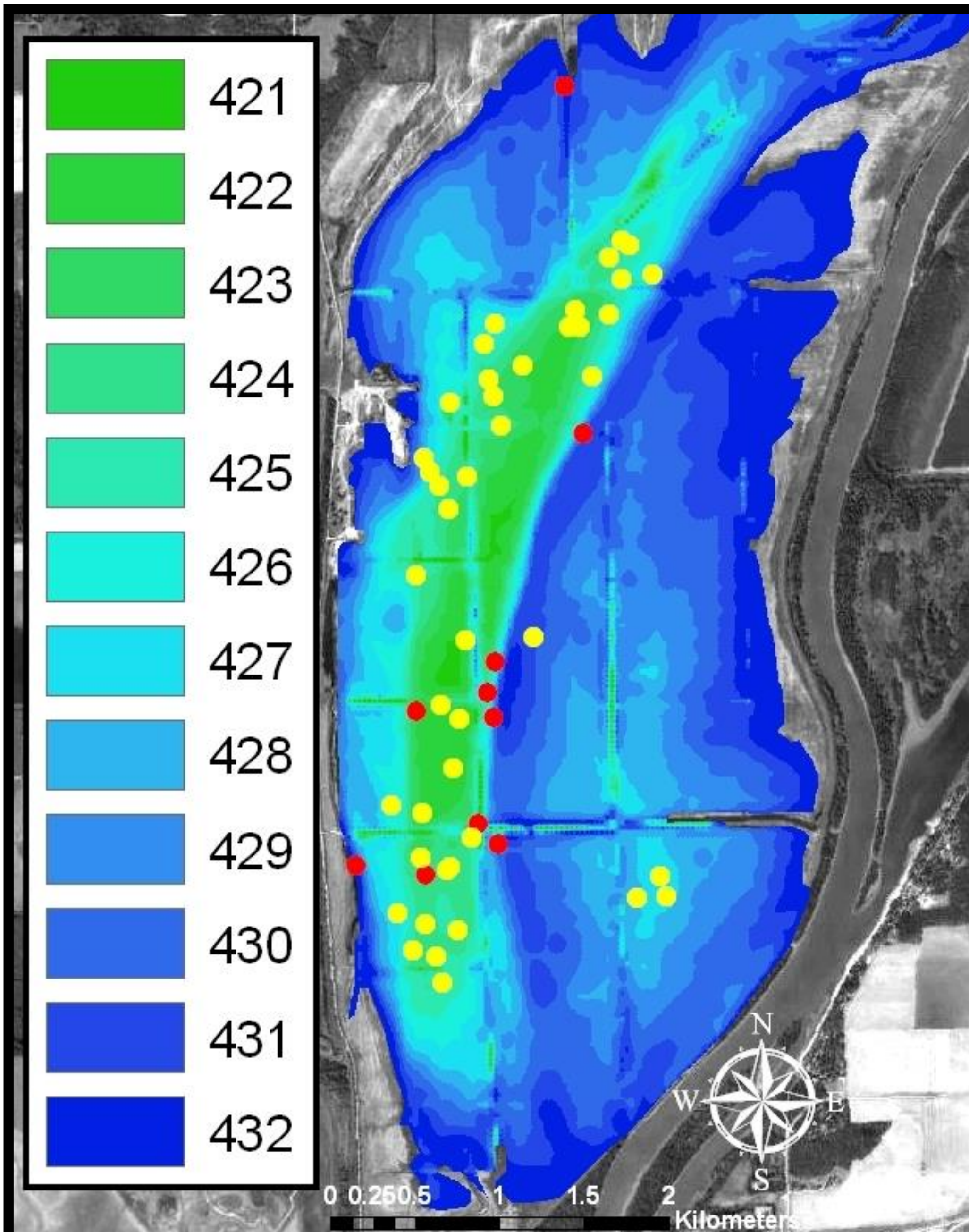


Figure 16. Relative weight (Wr) of gizzard shad (*Dorosoma cepedianum*) ≥100 mm collected from Thompson Lake in 2013. Red line represents 100% relative weight.



Key

Green = 9-12 ft of water

Yellow dots = Unvegetated aquatic vegetation sampling sites (May-October, 2012)

Red dots = Unvegetated fish sampling sites (April-October, 2012)

*Colored blocks represent water levels (421-432 ft asl)

Figure 17. Bathymetry of Thompson and Flag lakes at 432 ft asl displaying all un-vegetated aquatic vegetation and fish sampling sites between the months April-October, 2013.

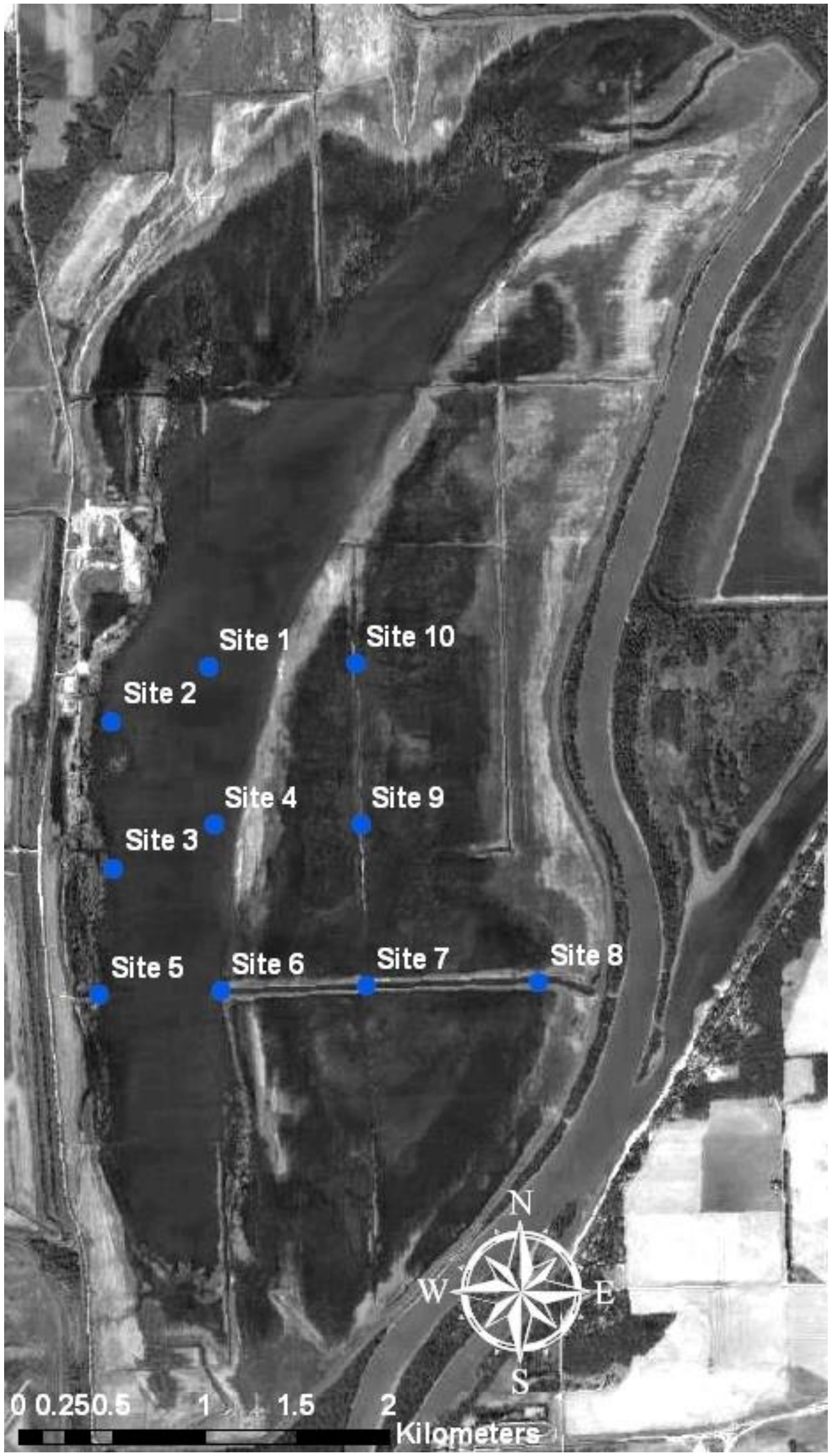
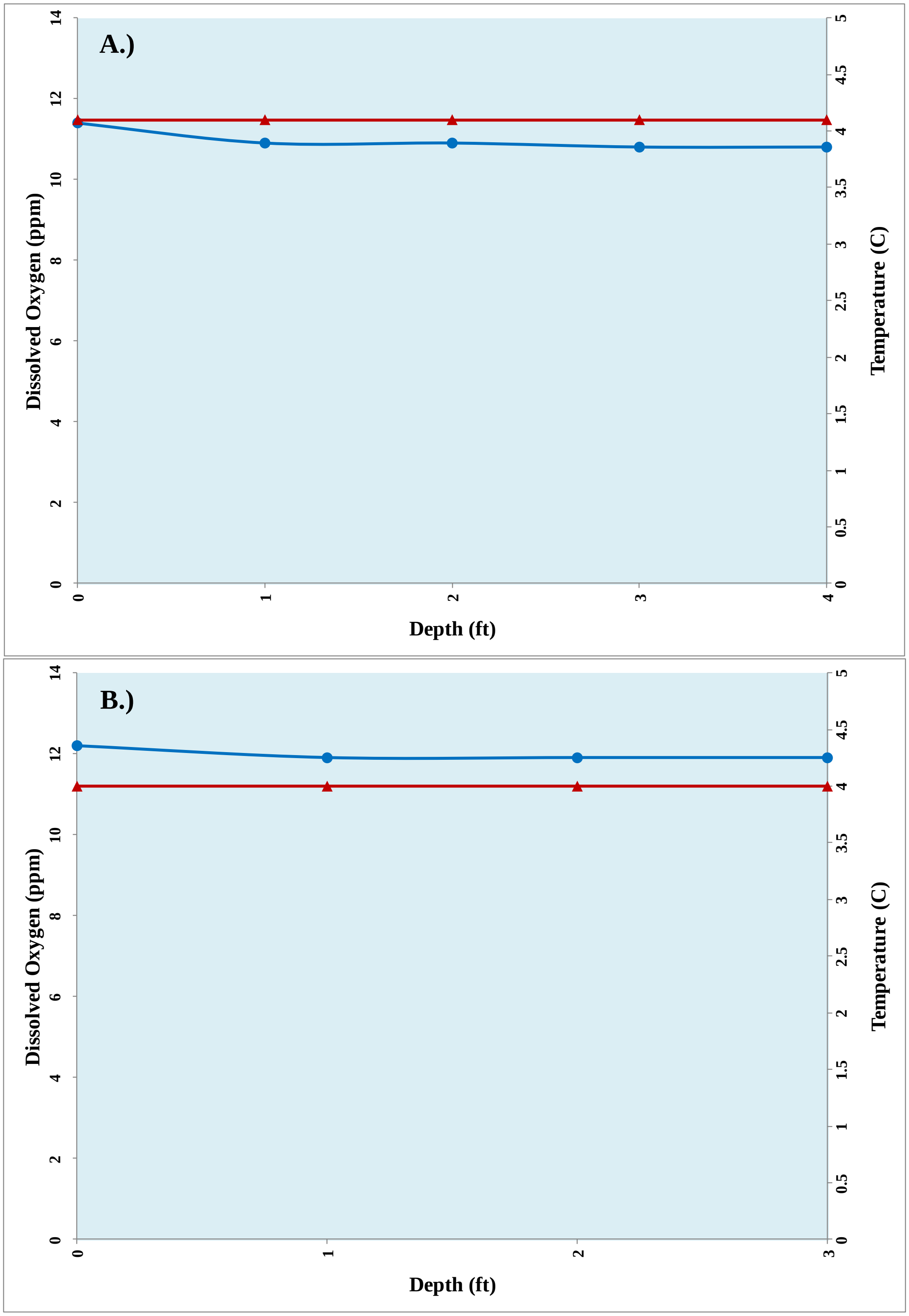
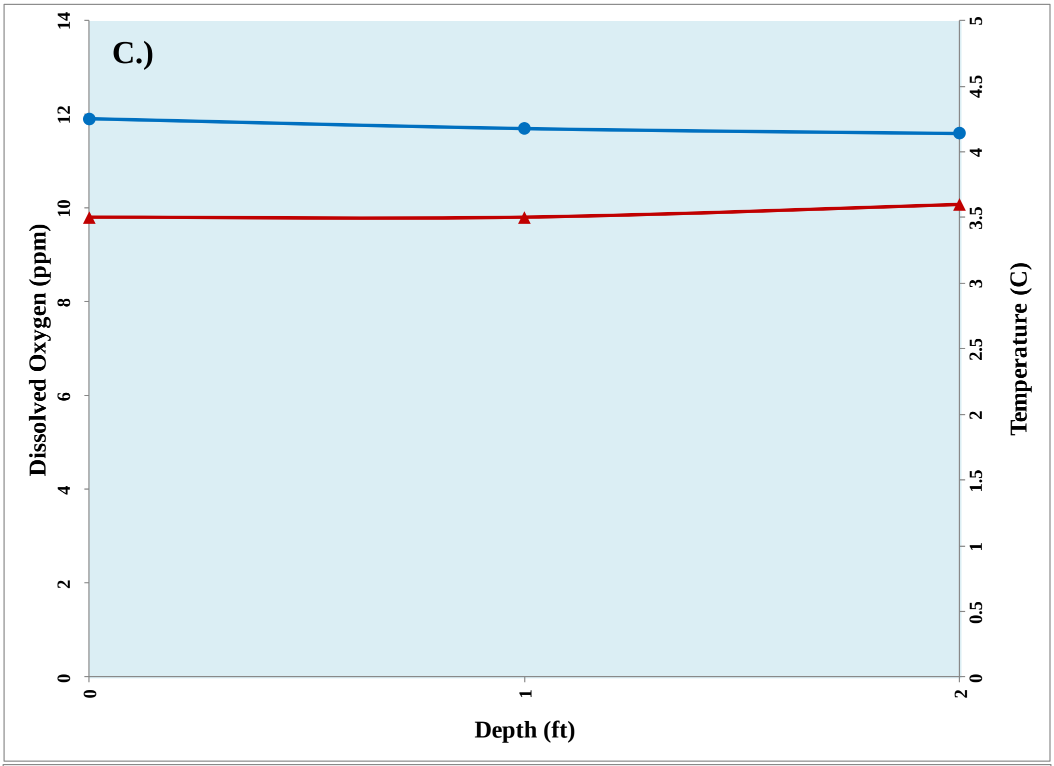
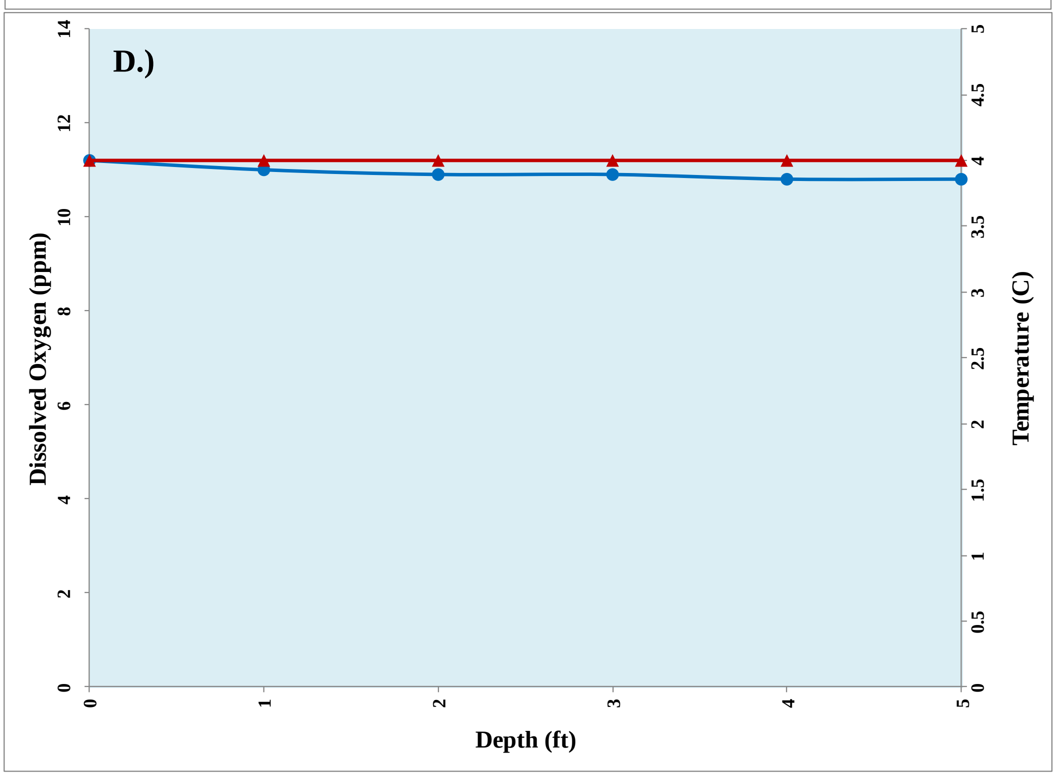


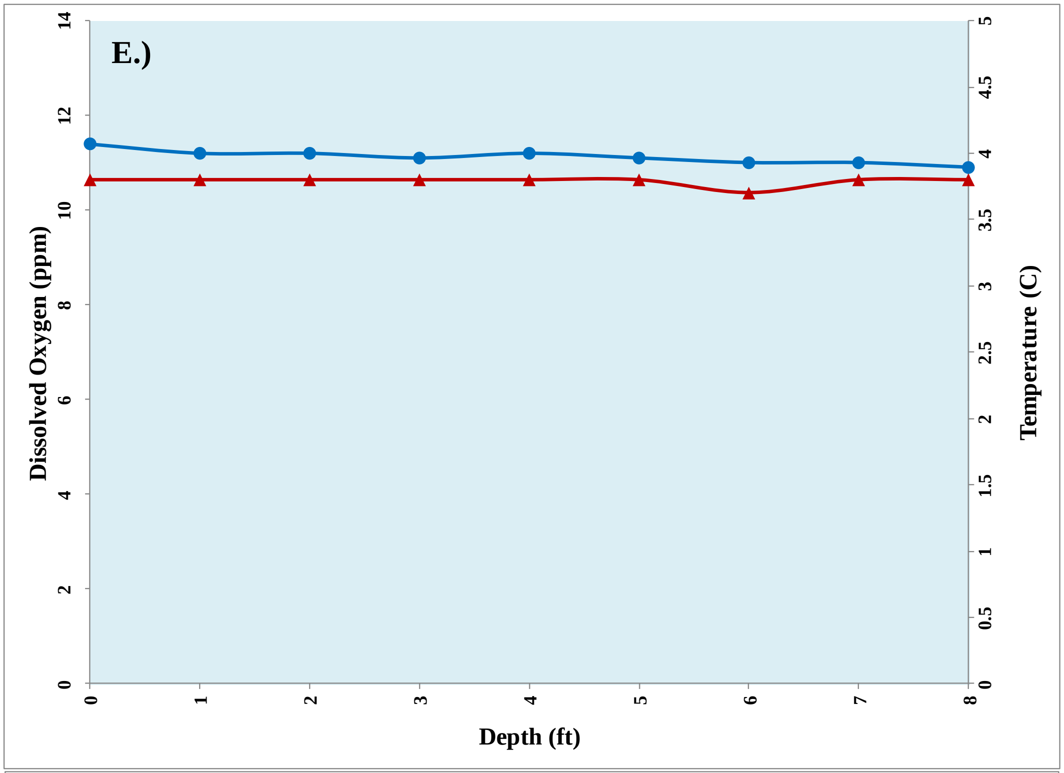
Figure 18. Map of Thompson and Flag lakes showing locations of dissolved oxygen (ppm)/temperature (°C) fixed sites collected on March 12, 2013.

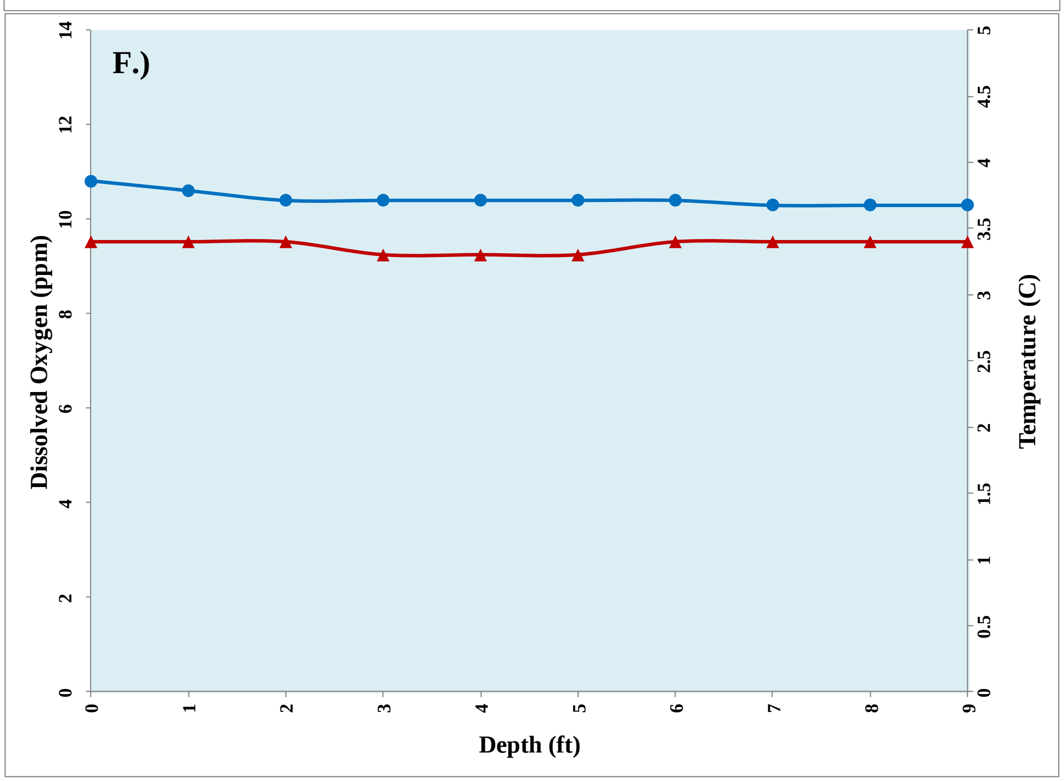
<u>Figure 19.</u> Dissolved oxygen (ppm)/temperature (°C) profiles collected at 10 fixed sites on March 12, 2013 (Site #1 = A, #2 = B, #3 = C, #4 = D, #5 = E, #6 = F, #7 = G, #8 = H, #9 = I, and #10 = J) (Dissolved oxygen (ppm) = blue, Temperature (°C) = red).

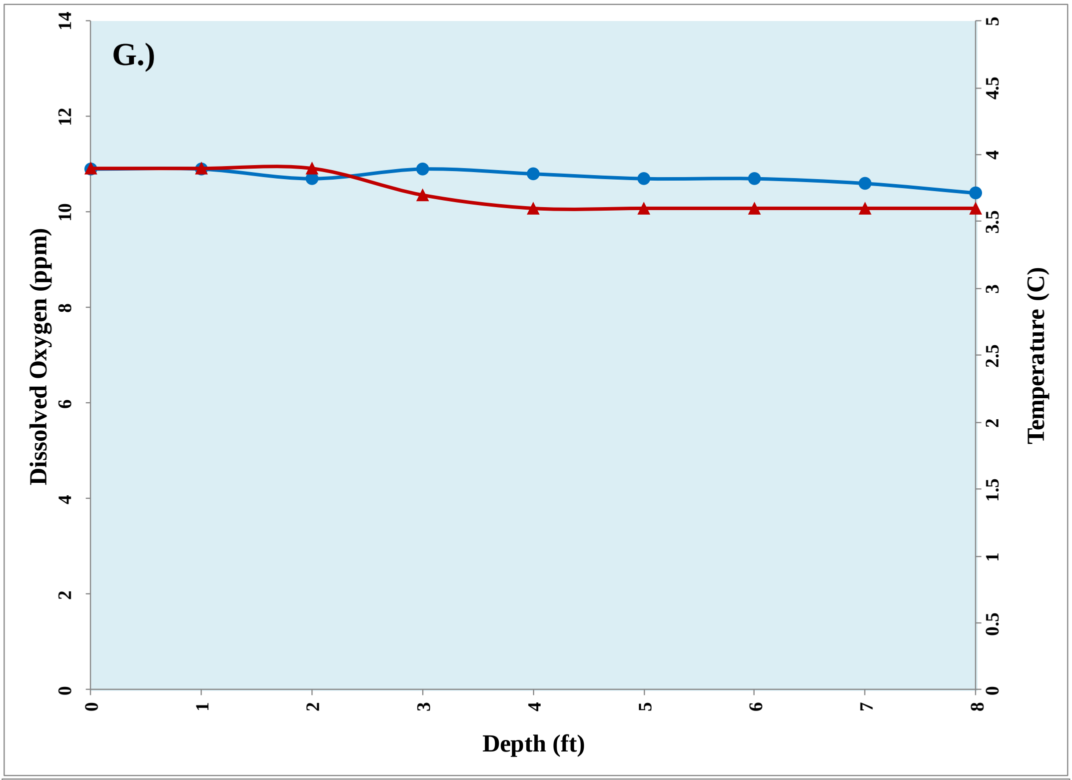


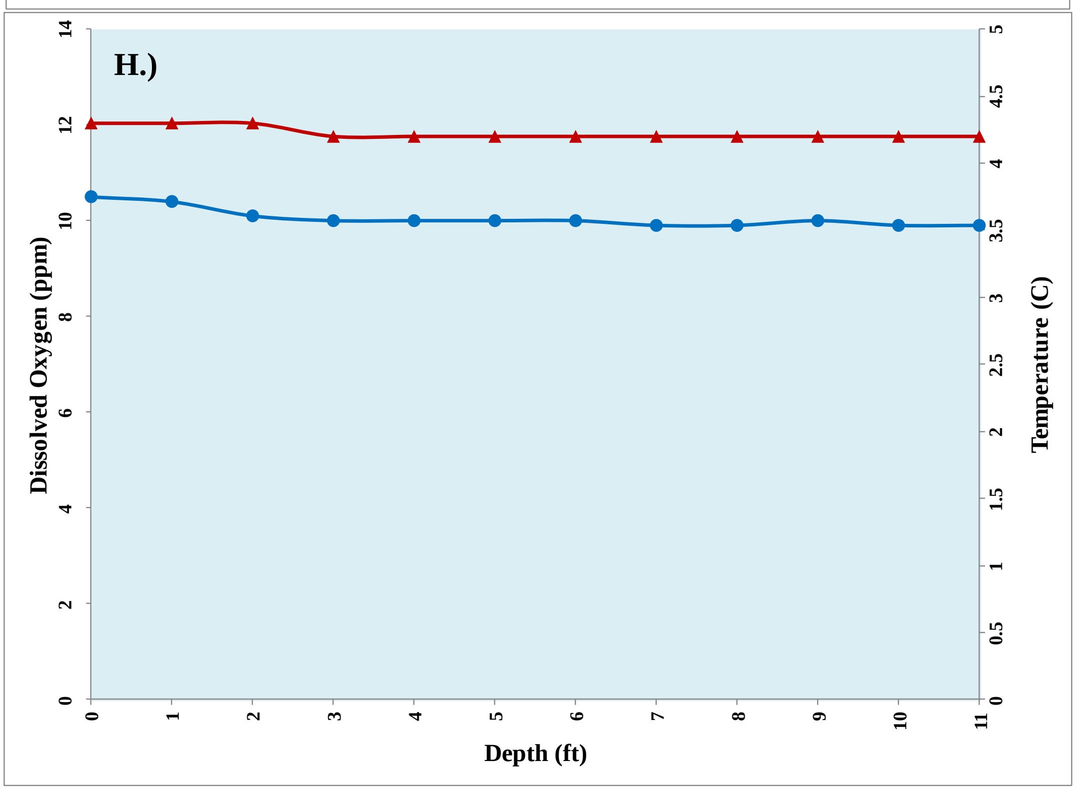

C.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)

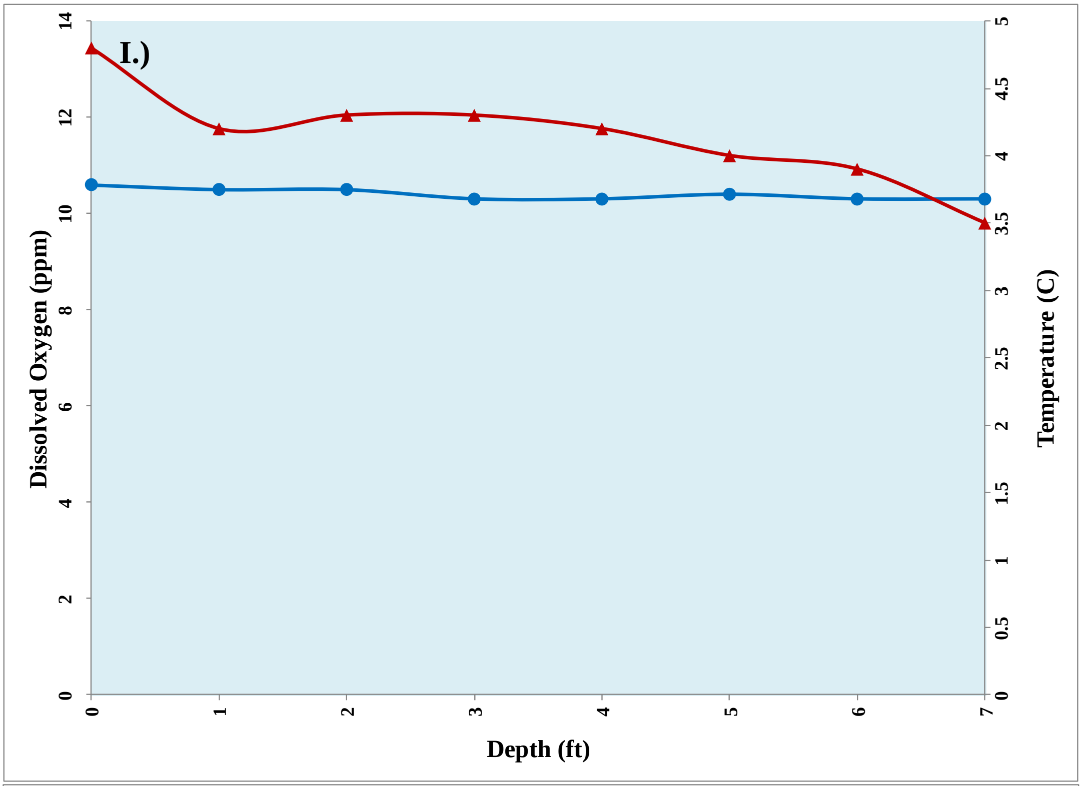

D.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)

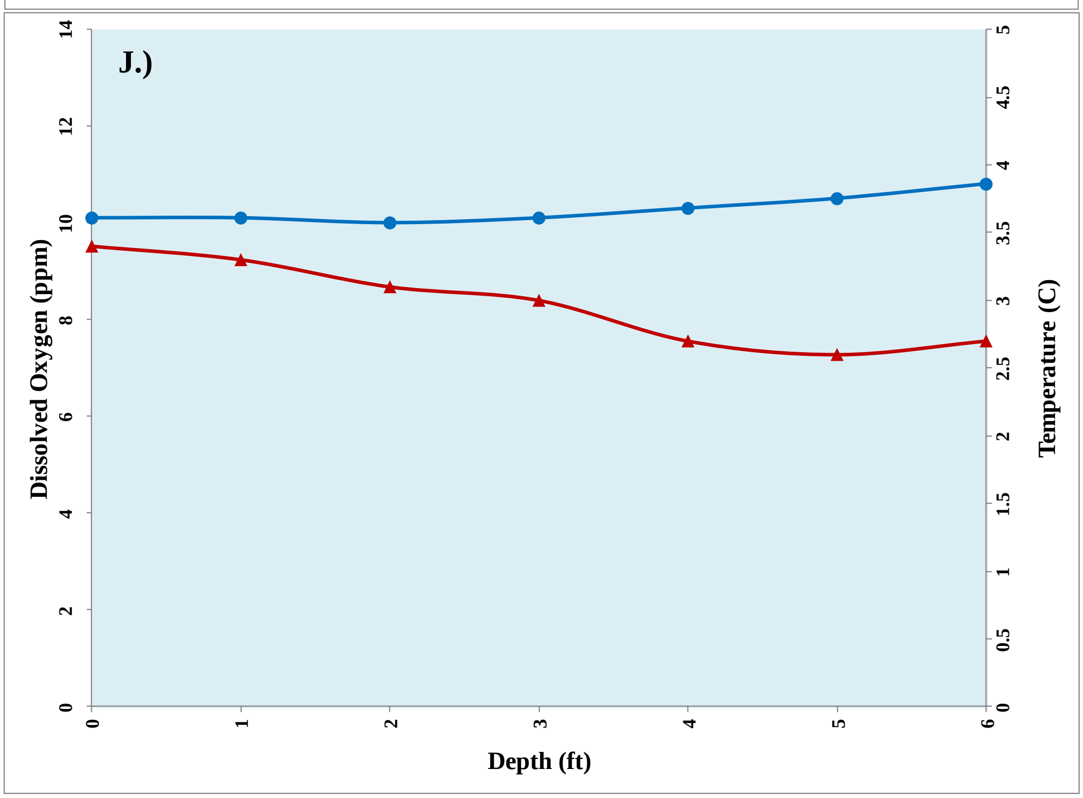

E.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)


F.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)


G.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)


H.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)


I.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)


J.)
Dissolved Oxygen (ppm)
Temperature (C)
Depth (ft)

<u>Figure 20.</u> Map of Thompson and Flag lakes showing locations of fixed electrofishing sites sampled on March 28, 2013.

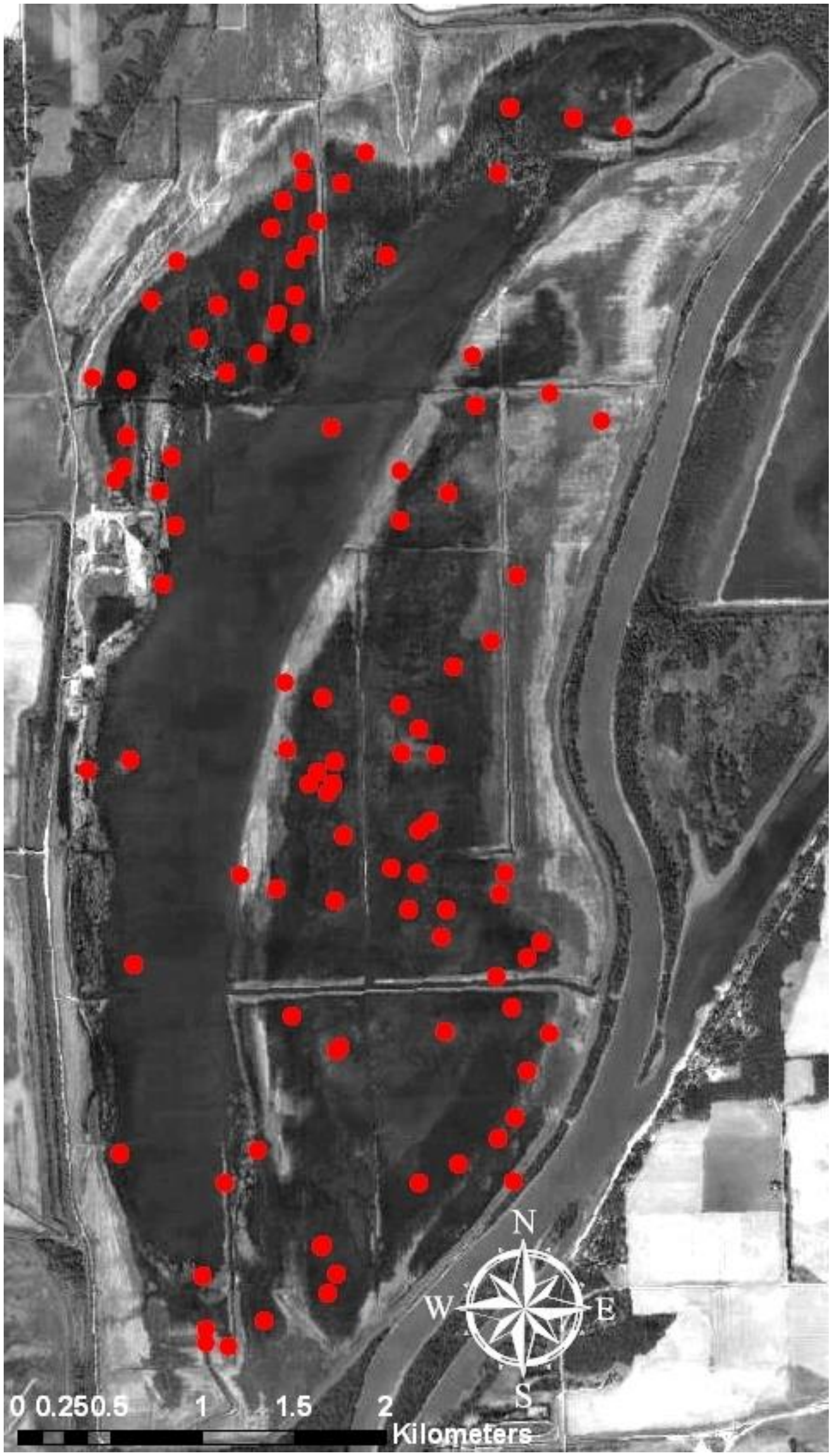


Figure 21. Map of Thompson and Flag lakes showing locations of Eurasian watermilfoil (*Myriophyllum spicatum*) collected in 2013 (101 out of 210 sites).

Figure 22. Map of Thompson and Flag lakes showing locations of curly-leaf pondweed (*Potamogeton crispus*) collected in 2013 (5 out of 210 sites).

Figure 23. Map of Thompson and Flag lakes showing locations of American lotus (*Nelumbo lutea*) observed in 2013 (34 observations).

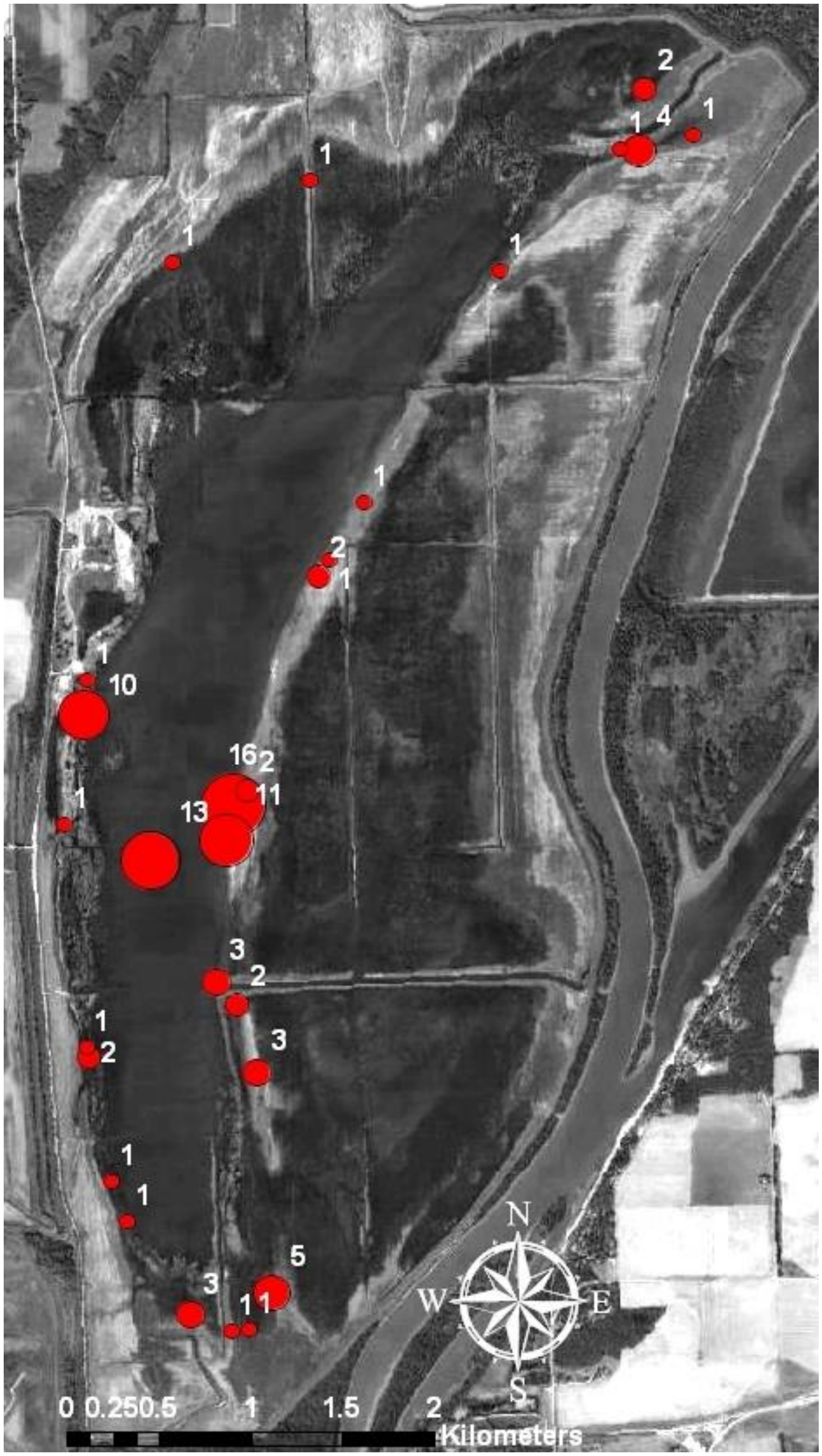


Figure 24. Map of Thompson and Flag lakes showing the locations and total catch of common carp (*Cyprinus carpio)* collected at random and fixed fish sampling sites in 2013.

<u>Appendix A. Table 1A representing all fish collected while electrofishing on March 28, 2013 to evaluate overwintering fish habitat.</u>

<u>Table 1A.</u> Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) of each species collected while electrofishing on March 28, 2013 to evaluate overwintering fish habitat; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	73	38	49
	bluegill	*Lepomis macrochirus*	Centrarchidae	51	27	34
	largemouth bass	*Micropterus salmoides*	Centrarchidae	34	18	23
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	9	5	6
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	8	4	5
	pumpkinseed	*L. gibbosus*	Centrarchidae	6	3	4
	white crappie	*P. annularis*	Centrarchidae	5	3	3
*	common carp	*Cyprinus carpio*	Cyprinidae	2	1	1
	bowfin	*Amia calva*	Amiidae	1	1	1
	warmouth	*L. gulosus*	Centrarchidae	1	1	1

Total Fish	**190**
Total Species	**10**
Total Families	**4**

Appendix B. Table 1B representing all fish observed by The Nature Conservancy while seining the south levee of the Emiquon Preserve during a historic flood event in April, 2013.

Table 1B. Fish species list of all specimens collected by The Nature Conservancy seining the south levee of the Emiquon Preserve during a historic flood event in April, 2013; * represents non-native species.

	Common name	Scientific name	Family
	bigmouth buffalo	*Ictiobus cyprinellus*	Catostomidae
	black bullhead	*Ameiurus melas*	Ictaluridae
*	common carp	*Cyprinus carpio*	Cyprinidae
	emerald shiner	*Notropis atherinoides*	Cyprinidae
	gizzard shad	*Dorosoma cepedianum*	Clupeidae
*	grass carp	*Ctenopharyngodon idella*	Cyprinidae
	largemouth bass	*Micropterus salmoides*	Centracrchidae
	red shiner	*Cyprinella lutrensis*	Cyprinidae
	shortnose gar	*Lepisosteus platostomus*	Lepisostidae
*	silver carp	*Hypopthalmichthys molitrix*	Cyprinidae
	silver chub	*Macrhybopsis storeiana*	Cyprinidae
	smallmouth buffalo	*Ictiobus bubalus*	Catostomidae
	western mosquitofish	*Gambusia affinis*	Poeciliidae

Appendix C. 2011 Reelfoot Lake Summary

Authors: T.D. VanMiddlesworth*, Bradley A. Ray, Greg G. Sass, and Timothy W. Spier

Introduction

We sampled the fish and aquatic vegetation communities at Reelfoot Lake in order to compare the system with the Emiquon Preserve. Reelfoot Lake has diverse fish and aquatic vegetation communities. It is similar to the Emiquon Preserve and other Illinois River backwater lakes in that it is a shallow floodplain lake that is disconnected from the mainstem river and maintains a non-native fish community, mainly common carp *Cyprinus carpio*. However, the native plant and animal communities seem to co-exist with the non-native fish community, while maintaining sufficient water clarity to produce dense aquatic vegetation communities. Our primary objective was to determine prey use of the most abundant piscivores in the system, which included largemouth bass *Micropterus salmoides*, spotted gar *Lepisosteus oculatus*, and bowfin *Amia calva* to test whether these fishes were preying upon common carp (TWRA 2009).

Methods

We sampled the fish and aquatic vegetation communities at Reelfoot Lake from 6/13/2011-6/16/2011. Reelfoot Lake is located near Samburg, TN, has a surface area of about 6,070 ha, and was formed in the early 1800s by a massive earthquake. The average depth is 5.2 feet (THS 2011) (TWRA, 2009, 2011). Fish and aquatic vegetation sampling was based on the U.S. Army Corps of Engineers Upper Mississippi River Restoration-Environmental Management Program (UMMR-EMP) Long Term Resource Monitoring Program (LTRMP) element protocols (Gutreuter et al. 1995) (Yin et al. 2000).

Fish

We used pulsed-DC electrofishing to sample fish at 50 sites in a variety of habitats for 15 minutes each. Bowfin, spotted gar, largemouth bass, and common carp were measured to the nearest mm and weighed to the nearest gram. Only length was collected for young-of-year (YOY) common carp, YOY gar species, and gizzard shad *Dorosoma cepedianum*. All other species were identified and enumerated only. Diets were extracted from bowfin and spotted gar by removing the entire gut of each fish, preserved in formalin, and stored for lab analysis. Largemouth bass diets were collected using a non-lethal gastric lavage technique. Otoliths were extracted from common carp for aging purposes.

Aquatic Vegetation

We sampled submersed, emergent, and floating leaved aquatic vegetation using an LTRMP style vegetation rake and visual observations at 2 locations within 2 m of both sides of the boat at each site. The presence of submersed, emergent, and floating-leaved aquatic vegetation was recorded for each rake.

Water Quality

Ancillary water quality measurements (surface water temperature (^{o}C), dissolved oxygen (ppm), conductivity µS)) were taken at each site using a YSI 85.

Results

Fish Catch

We collected 2,317 fishes consisting of 29 species and 14 families while electrofishing. Golden shiner *Notemigonus crysoleucas* dominated the catch with 576 fish comprising 24.9% of the total catch followed by gizzard shad (369, 15.9%), largemouth bass (295, 12.7%), bluegill *Lepomis macrochirus* (247, 10.7%), freshwater drum *Aplodinotus grunniens* (124, 5.4%), spotted gar (86, 3.7%), common carp (85, 3.7%), bowfin (84, 3.6%), warmouth *L. gulosus* (84, 3.6%), channel catfish *Ictalurus punctatus* (77, 3.3%), YOY unidentified gar spp. (likely spotted gar) (54, 2.3%), orangespotted sunfish *L. humilis* (50, 2.2%), yellow bass *Morone mississippiensis* (49, 2.1%), black crappie *Pomoxis nigromaculatus* (41, 1.8%), bigmouth buffalo *Ictiobus cyprinellus* (34, 1.5%), brook silverside *Labidesthes sicculus* (23, 1.0%), flier *Centrarchus macropterus* (8, 0.3%), longear sunfish *L. megalotis* (7, 0.3%), white crappie *P. annularis* (4, 0.2%), starhead topminnow *Fundulus dispar* (3, 0.1%), yellow bullhead *Ameiurus natalis* (3, 0.1%), green sunfish *L. cyanellus* (2, 0.1%), golden topminnow *Fundulus chrysotus* (2, 0.1%), western mosquitofish *Gambusia affinis* (2, 0.1%), taillight shiner *Notropis maculates* (2, 0.1%), black bullhead *Ameiurus melas* (1, <0.1%), grass pickerel *Esox americanus* (1, <0.1%), pirate perch *Aphredoderus sayanus* (1, <0.1%), redear sunfish *L. microlophus* (1, <0.1%), smallmouth buffalo *I. bubalus* (1, <0.1%), and YOY unidentified catostomid spp. (likely buffalo spp.) (1, <0.1%). Common carp was the only non-native species collected. Of the total common carp collected, 15 were YOY with lengths 50-80 mm (Table 1C).

Catch per unit effort was calculated based on 12.5 hrs of electrofishing (pedal time). Golden shiner dominated the catch with 46 fish/hr followed by 30 gizzard shad/hr, 24 largemouth bass/hr, 20 bluegill/hr, 10 freshwater drum/hr, 8 common carp, 7 spotted gar, bowfin, and warmouth/hr, 6 channel catfish/hr, 4 YOY unidentified gar spp. (likely spotted gar)/hr, 4 orangespotted sunfish/hr, 4 yellow bass/hr, 3 black crappie and bigmouth buffalo/hr, 2 brook silverside/hr, 1 flier and longear sunfish/hr, and <1 white crappie, starhead topminnow, yellow bullhead, green sunfish, golden topminnow, western mosquitofish, tailight shiner, black bullhead, grass pickerel, pirate perch, redear sunfish, smallmouth buffalo, and YOY unidentified catostomid spp. (likely buffalo spp.)/hr (Table 1C).

Fish Diets

We collected 72 bowfin, 55 spotted gar, and 19 largemouth bass diets from Reelfoot Lake during 2011. Out of these diets, we found no evidence of predation on common carp (Figure 1C, 2C, 3C).

Aquatic Vegetation

We collected and/or observed 8 aquatic plant species (emergent, floating-leaved, and submersed) total out of all but two of the 50 sampling sites. Emergent aquatic vegetation was present at 29 out of 50 sites and included *Typha* species. Only one non-rooted, floating-leaved family Lemnaceae was present at 45 out of 50 sites. Rooted floating-leaved species were present at 35 out of 50 sites and included American lotus *Nelumbo lutea* and spatterdock *Nuphar luteum*. Submersed species were present at 10 out of 50 sites and included bladderwort *Utricularia vulgaris*, coontail *Ceratophyllum demersum*, leafy pondweed *Potamogeton foliosus*, and American pondweed *Potamogeton nodosus*. Filamentous algae was present at only 2 out of 50 sites. Flooded cypress trees were present at all 50 sites and woody debris/snags excluding cypress trees were present at over half of the sites we sampled. Most sites had a silt/clay substrate, with fewer sites having silt or a rock substrate.

Water Quality

We recorded water quality parameters at all 50 electrofishing sites. On average, water temperature was 28.3 °C, dissolved oxygen was 3.7 ppm, and depth was 0.9 m. Secchi disc transparencies had a mean of 48 cm. Overall, Secchi disc transparencies were no less than half the maximum water depth at 32 out of 50 sites.

Discussion

Reelfoot Lake had a largemouth bass CPUE less than that of the Emiquon Preserve and bowfin and spotted gar CPUE greater than that of the Emiquon Preserve. Fish species richness was much greater at Reelfoot Lake than at the Emiquon Preserve. Rooted floating-leaved aquatic vegetation was abundant at Reelfoot Lake, whereas submersed aquatic vegetation was abundant at the Emiquon Preserve. Other structure, including woody debris density, was greater at Reelfoot Lake than at the Emiquon Preserve.

Although no evidence of common carp predation was found in the diets collected from Reelfoot Lake in 2011, the above mentioned differences may reveal a mechanism as to how this shallow lake has maintained a healthy aquatic ecosystem for so many years while being inhabited by common carp. Reelfoot Lake serves as a model ecosystem to compare to the Emiquon Preserve. Although this was only a week long study, our observations and collections may suggest that Reelfoot Lake may be a balanced aquatic ecosystem where native fish species control non-native common carp indirectly through unknown pathways and inhibit them from having negative effects on the ecosystem. In order to learn more from this lake, another study would be appropriate in the summer of 2012.

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Yin, Y., J.S. Winkelman, and H.A. Langrehr. 2000. Long Term Resource Monitoring Program Procedures: Aquatic Vegetation Monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI.

Table 1C. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Reelfoot Lake in 2011; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	576	24.9	46
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	369	15.9	30
	largemouth bass	*Micropterus salmoides*	Centrarchidae	295	12.7	24
	bluegill	*Lepomis macrochirus*	Centrarchidae	247	10.7	20
	freshwater drum	*Aplodinotus grunniens*	Sciaenidae	124	5.4	10
	spotted gar	*Lepisosteus oculatus*	Lepisosteidae	86	3.7	7
*	common carp	*Cyprinus carpio*	Cyprinidae	85	3.7	7
	bowfin	*Amia calva*	Amiidae	84	3.6	7
	warmouth	*L. gulosus*	Centrarchidae	84	3.6	7
	channel catfish	*Ictalurus punctatus*	Ictaluridae	77	3.3	6
	(YOY) unidentified gar spp.	Lepisosteus spp.	Lepisosteidae	54	2.3	4
	orangespotted sunfish	*L. humilis*	Centrarchidae	50	2.2	4
	yellow bass	*Morone mississippiensis*	Moronidae	49	2.1	4
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	41	1.8	3
	bigmouth buffalo	*Ictiobus cyprinellus*	Catostomidae	34	1.5	3
	brook silverside	*Labidesthes sicculus*	Atherinidae	23	1.0	2
	flier	*Centrarchus macropterus*	Centrarchidae	8	0.3	1
	longear sunfish	*L. megalotis*	Centrarchidae	7	0.3	1
	white crappie	*P. annularis*	Centrarchidae	4	0.2	<1
	starhead topminnow	*Fundulus dispar*	Fundulidae	3	0.1	<1
	yellow bullhead	*Ameiurus natalis*	Ictaluridae	3	0.1	<1
	green sunfish	*L. cyanellus*	Centrarchidae	2	0.1	<1
	golden topminnow	*Fundulus chrysotus*	Fundulidae	2	0.1	<1
	western mosquitofish	*Gambusia affinis*	Poeciliidae	2	0.1	<1
	taillight shiner	*Notropis maculatus*	Cyprinidae	2	0.1	<1
	black bullhead	*Ameiurus melas*	Ictaluridae	1	0.0	<1
	grass pickerel	*Esox americanus*	Esocidae	1	0.0	<1
	pirate perch	*Aphredoderus sayanus*	Aphredoderidae	1	0.0	<1
	redear sunfish	*L. microlophus*	Centrarchidae	1	0.0	<1
	smallmouth buffalo	*I. bubalus*	Catostomidae	1	0.0	<1
	(YOY) unidentified Catostomidae spp.	*Ictiobus* spp.	Catostomidae	1	0.0	<1

Total Fish	**2317**
Species	**29**
Families	**14**

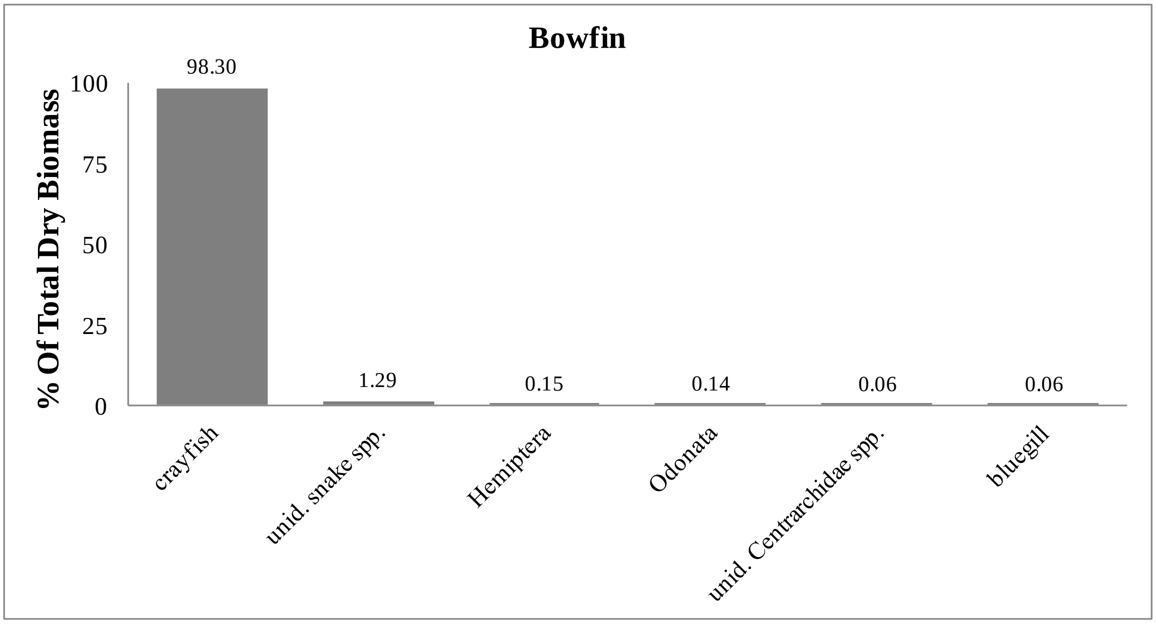

Figure 1C. % of total dry biomass of each prey item collected from 72 bowfin *Amia calva* at Reelfoot Lake in 2011.

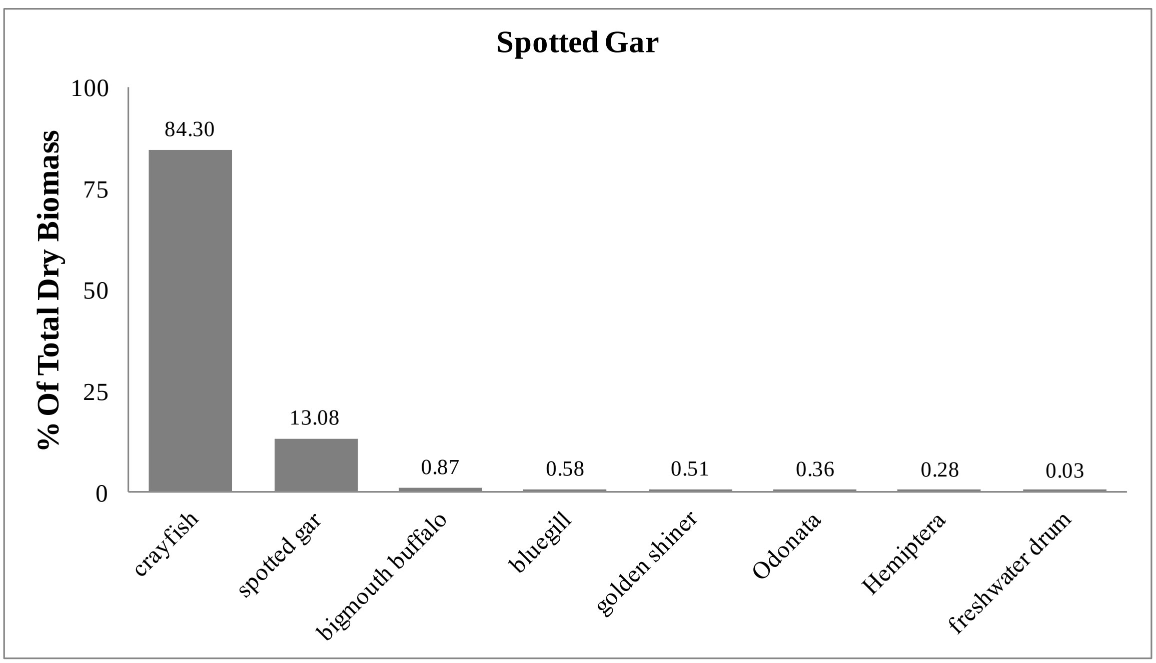

Figure 2C. % of total dry biomass of each prey item collected from 55 spotted gar *Lepisosteus oculatus* at Reelfoot Lake in 20

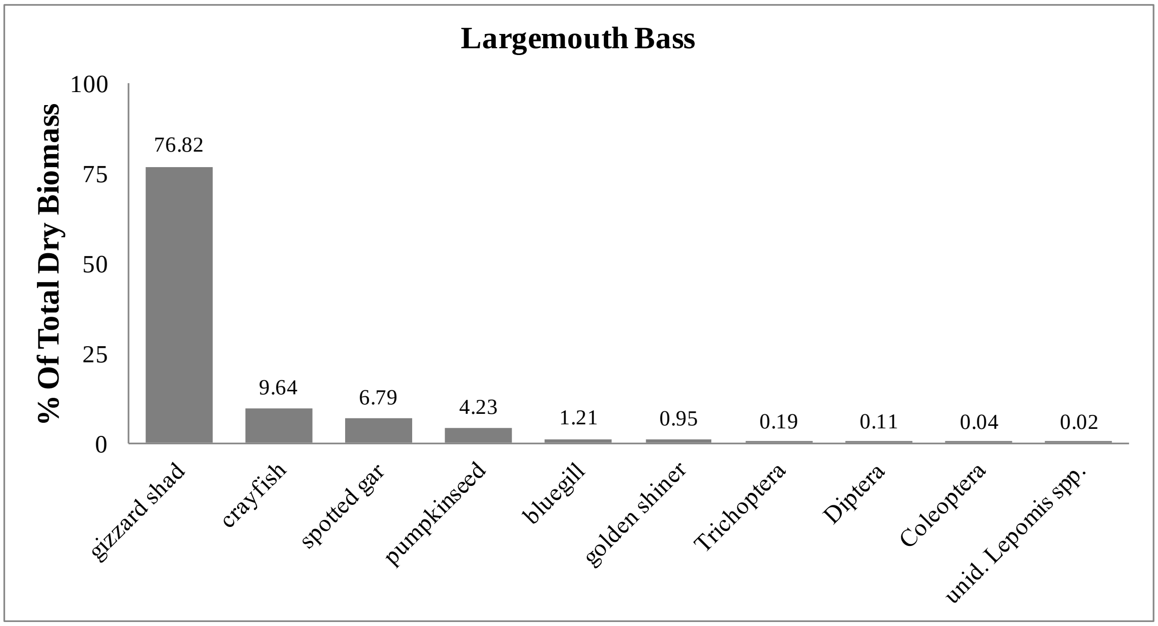

Figure 3C. % of total dry biomass of each prey item collected from 19 largemouth bass *Micropterus salmoides* at Reelfoot Lake in 2011.

Appendix D. 2012 Reelfoot Lake Summary

Authors: T.D. VanMiddlesworth*, Bradley A. Ray, Greg G. Sass, and Timothy W. Spier

Introduction

We sampled the fish and aquatic vegetation communities at Reelfoot Lake to expand upon our 2011 findings and compare the system with the Emiquon Preserve. Reelfoot Lake has diverse fish and aquatic vegetation communities. It is similar to the Emiquon Preserve and other Illinois River backwater lakes in that it is a shallow floodplain lake that is disconnected from the mainstem river and maintains a non-native fish community including common carp *Cyprinus carpio*. However, the native plant and fish communities seem to co-exist with the non-native fish community, while maintaining sufficient water clarity to produce dense aquatic vegetation in Reelfoot Lake. Our primary objective was to determine prey use of the most abundant piscivores in the system, which included bowfin *Amia calva*, largemouth bass *Micropterus salmoides*, and spotted gar *Lepisosteus oculatus* to test whether these fishes were preying upon common carp (TWRA 2009).

Methods

We sampled the fish and aquatic vegetation communities at Reelfoot Lake from 6/12/2012-6/14/2012. Reelfoot Lake is located near Samburg, TN, has a surface area of about 6,070 ha, and was formed in the early 1800s by a massive earthquake. The average depth is 5.2 feet (THS 2012) (TWRA, 2009, 2012). Fish and aquatic vegetation sampling was based on the U.S. Army Corps of Engineers Upper Mississippi River Restoration-Environmental Management Program (UMMR-EMP) Long Term Resource Monitoring Program (LTRMP) element protocols (Gutreuter et al. 1995) (Yin et al. 2000).

Fish

We used pulsed-DC electrofishing to sample fish at 50 sites in a variety of habitats for 15 minutes each. Largemouth bass, bowfin, spotted gar, and common carp were measured to the nearest mm and weighed to the nearest gram. Only length was collected for young-of-year (YOY) largemouth bass, YOY gar species, gizzard shad *Dorosoma cepedianum*, flathead catfish *Pylodictis olivaris*, and grass carp *Ctenopharyngodon idella*. All other species were identified and enumerated only. Diets were extracted from bowfin and spotted gar by removing the entire gut of each fish, preserved in formalin, and stored for lab analysis. Largemouth bass diets were collected using a non-lethal gastric lavage technique.

Aquatic Vegetation

We sampled submersed, emergent, and floating leaved aquatic vegetation using an LTRMP style vegetation rake and visual observations at 2 locations within 2 m of both sides of the boat at each site. The presence of submersed, emergent, and floating-leaved aquatic vegetation was recorded for each rake.

Water Quality

Ancillary water quality measurements (surface water temperature (^oC), dissolved oxygen (ppm), conductivity (µS)) were taken at each site using a YSI 85.

Results

Fish Catch

We collected 5,148 fishes consisting of 28 species and 14 families while electrofishing. Gizzard shad dominated the catch with 2,371 fish comprising 46.1% of the total catch followed by bluegill *Lepomis macrochirus* (855, 16.6%), yellow bass *Morone mississippiensis* (394, 7.7%), brook silverside *Labidesthes sicculus* (319, 6.2%), bowfin (183, 3.6%), western mosquitofish *Gambusia affinis* (170, 3.3%), freshwater drum *Aplodinotus grunniens* (151, 2.9%), golden shiner *Notemigonus crysoleucas* (130, 2.5%), largemouth bass (110, 2.1%), warmouth *L. gulosus* (104, 2.0%), orangespotted sunfish *L. humilis* (92, 1.8%), spotted gar (86, 1.6%), black crappie *Pomoxis nigromaculatus* (49, 1.0%), channel catfish *Ictalurus punctatus* (49, 1.0%), pumpkinseed *L. gibbosus* (20, 0.4%), common carp (14, 0.3%), white crappie *P. annularis* (14, 0.3%), flier *Centrarchus macropterus* (11, 0.2%), longear sunfish *L. megalotis* (7, 0.1%), bigmouth buffalo *Ictiobus cyprinellus* (4, 0.1%), green sunfish *L. cyanellus* (3, 0.1%), pirate perch *Aphredoderus sayanus* (3, 0.1%), green sunfish x bluegill *L. cyanellus x L. macrochirus* (2, <0.1%), grass carp (2, <0.1%), grass pickerel *Esox americanus* (2, <0.1%), golden topminnow *Fundulus chrysotus* (2, <0.1%), taillight shiner *Notropis maculates* (2, <0.1%), chain pickerel *Esox niger* (1, <0.1%), and flathead catfish (1, <0.1%). Common carp and grass carp were the only non-native species collected. No YOY (<100 mm) common carp or grass carp were collected during our sampling of Reelfoot Lake in 2012 (Table 1D).

Catch per unit effort was calculated based on 12.5 hrs of electrofishing (pedal time). Gizzard shad dominated the catch with 190 fish/hr followed by 68 bluegill/hr, 32 yellow bass/hr, 26 brook silverside/hr, 15 bowfin/hr, 14 western mosquitofish/hr, 12 freshwater drum/hr, 10 golden shiner/hr, 9 largemouth bass/hr, 8 warmouth/hr, 7 orangespotted sunfish and spotted gar/hr, 4 black crappie and channel catfish/hr, 2 pumpkinseed/hr, 1 common carp, white crappie, flier, and longear sunfish/hr, and <1 bigmouth buffalo, green sunfish, pirate perch, greensunfish x bluegill, grass carp, grass pickerel, golden topminnow, taillight shiner, chain pickerel, and flathead catfish/hr (Table 1D).

Fish Diets

We collected 179 bowfin, 76 spotted gar, and 48 largemouth bass diets from Reelfoot Lake during 2012. Out of these diets, we found no evidence of predation on common carp (Figure 1D, 2D, 3D).

Aquatic Vegetation

We collected and/or observed 7 aquatic plant species (emergent, floating-leaved, and submersed) total out of all 50 sampling sites. Emergent aquatic vegetation was present at 41 out of 50 sites and included *Typha* and *Sagittaria* species. Only one non-rooted, floating-leaved family Lemnaceae was present at 5 out of 50 sites. Rooted floating-leaved species were present at 29 out of 50 sites and included American lotus *Nelumbo lutea*. Submersed species were present at 12 out of 50 sites and included bladderwort *Utricularia vulgaris*, coontail *Ceratophyllum demersum*, creeping water primrose *Jussiaea repens*, and American elodea *Elodea canadensis*. Flooded cypress trees were present at all 50 sites and woody debris/snags excluding cypress trees were present at over half of the sites we sampled. Most sites had a silt/clay substrate, with fewer sites having sand or a hard clay substrate.

Water Quality

We recorded water quality parameters at all 50 electrofishing sites. On average, water temperature was 26.6 °C, dissolved oxygen was 5.1 ppm, and depth was 0.8 m. Secchi disc transparencies had a mean of 22 cm. Overall, Secchi disc transparencies were less than half the maximum water depth at all 50 sites.

Discussion

Reelfoot Lake had a largemouth bass CPUE less than that of the Emiquon Preserve and bowfin and spotted gar CPUE greater than that of the Emiquon Preserve. Fish species richness was much greater at Reelfoot Lake than at the Emiquon Preserve. Emergent aquatic vegetation was abundant at Reelfoot Lake, whereas submersed aquatic vegetation was abundant at the Emiquon Preserve. Other structure, including woody debris density, was greater at Reelfoot Lake than at the Emiquon Preserve.

Although no evidence of common carp predation was found in the diets collected from Reelfoot Lake in 2012, the above mentioned differences may reveal a mechanism as to how this shallow lake has maintained a healthy aquatic ecosystem for so many years while being inhabited by common carp. Reelfoot Lake serves as a model ecosystem to compare to the Emiquon Preserve. Although this was only our second week long study, our observations and collections may suggest that Reelfoot Lake may be a balanced aquatic ecosystem where native fish species control non-native common carp indirectly through unknown pathways and inhibit them from having negative effects on the ecosystem. In order to learn more from this lake, another study would be appropriate in the summer of 2013.

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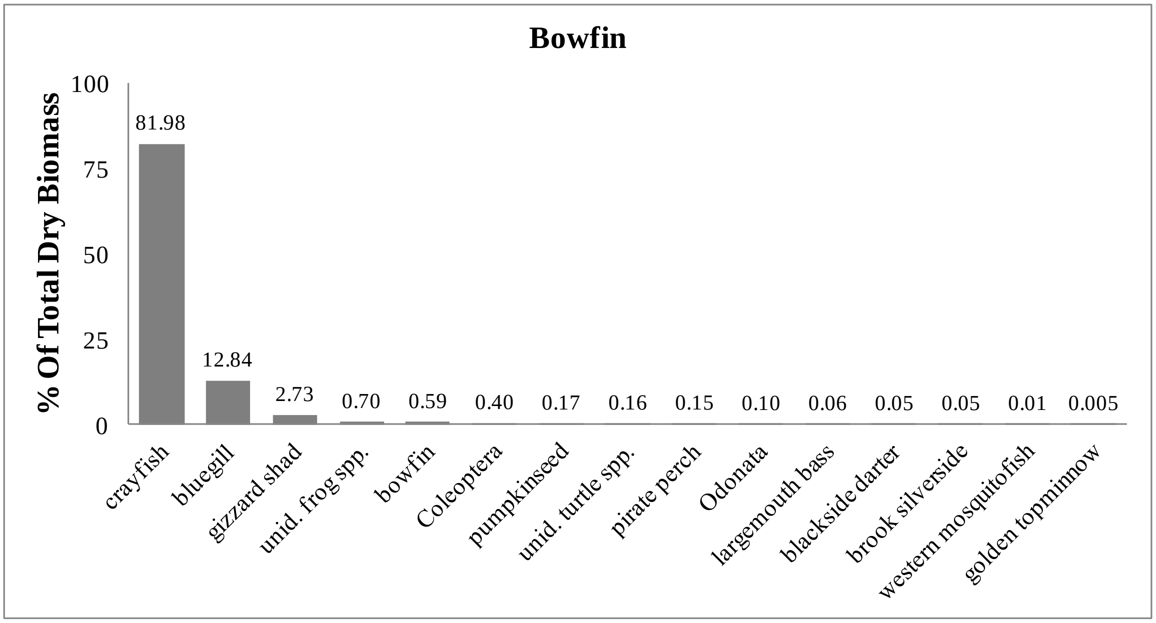
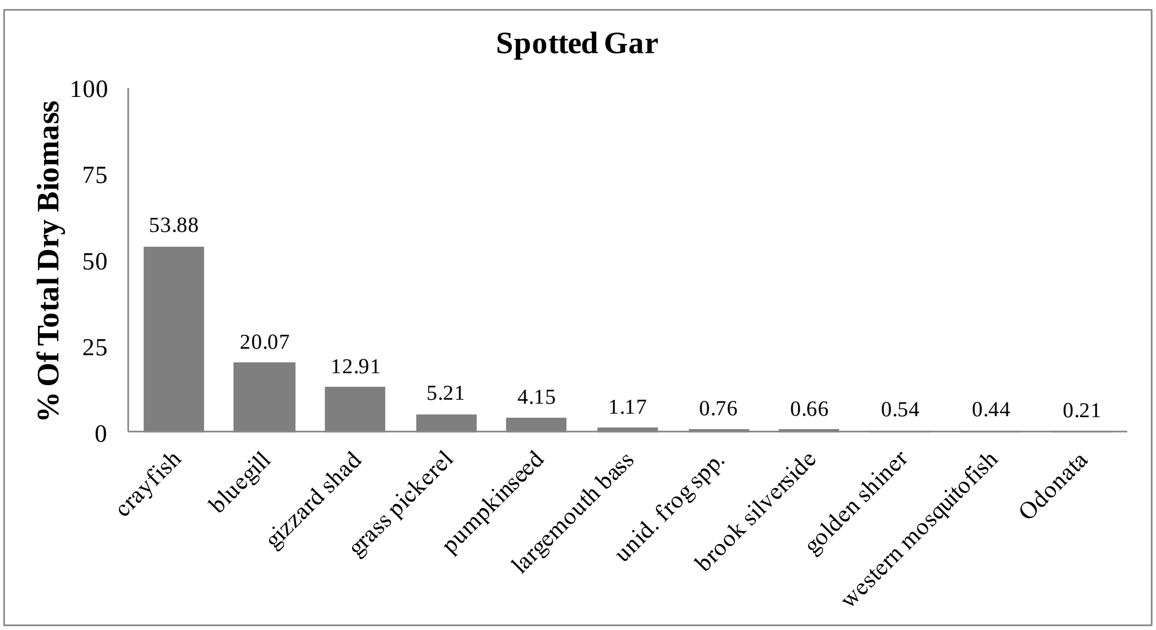
Table 1D. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Reelfoot Lake in 2012; * represents non-native species.

	Common Name	Scientific Name	Family	No.	%	CPUE
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	2371	46.1	190
	bluegill	*Lepomis macrochirus*	Centrarchidae	855	16.6	68
	yellow bass	*Morone mississippiensis*	Moronidae	394	7.7	32
	brook silverside	*Labidesthes sicculus*	Atherinidae	319	6.2	26
	bowfin	*Amia calva*	Amiidae	183	3.6	15
	western mosquitofish	*Gambusia affinis*	Poeciliidae	170	3.3	14
	freshwater drum	*Aplodinotus grunniens*	Sciaenidae	151	2.9	12
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	130	2.5	10
	largemouth bass	*Micropterus salmoides*	Centrarchidae	110	2.1	9
	warmouth	*L. gulosus*	Centrarchidae	104	2.0	8
	orangespotted sunfish	*L. humilis*	Centrarchidae	92	1.8	7
	spotted gar	*Lepisosteus oculatus*	Lepisosteidae	83	1.6	7
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	49	1.0	4
	channel catfish	*Ictalurus punctatus*	Ictaluridae	49	1.0	4
	pumpkinseed	*L. gibbosus*	Centrarchidae	20	0.4	2
*	common carp	*Cyprinus carpio*	Cyprinidae	14	0.3	1
	white crappie	*P. annularis*	Centrarchidae	14	0.3	1
	flier	*Centrarchus macropterus*	Centrarchidae	11	0.2	1
	longear sunfish	*L. megalotis*	Centrarchidae	7	0.1	1
	bigmouth buffalo	*Ictiobus cyprinellus*	Catostomidae	4	0.1	<1
	green sunfish	*L. cyanellus*	Centrarchidae	3	0.1	<1
	pirate perch	*Aphredoderus sayanus*	Aphredoderidae	3	0.1	<1
	green sunfish x bluegill	*L. cyanellus x L. macrochirus*	Centrarchidae	2	0.0	<1
*	grass carp	*Ctenopharyngodon idella*	Cyprinidae	2	0.0	<1
	grass pickerel	*Esox americanus*	Esocidae	2	0.0	<1
	golden topminnow	*Fundulus chrysotus*	Fundulidae	2	0.0	<1
	taillight shiner	*Notropis maculatus*	Cyprinidae	2	0.0	<1
	chain pickerel	*Esox niger*	Esocidae	1	0.0	<1
	flathead catfish	*Pylodictis olivaris*	Ictaluridae	1	0.0	<1

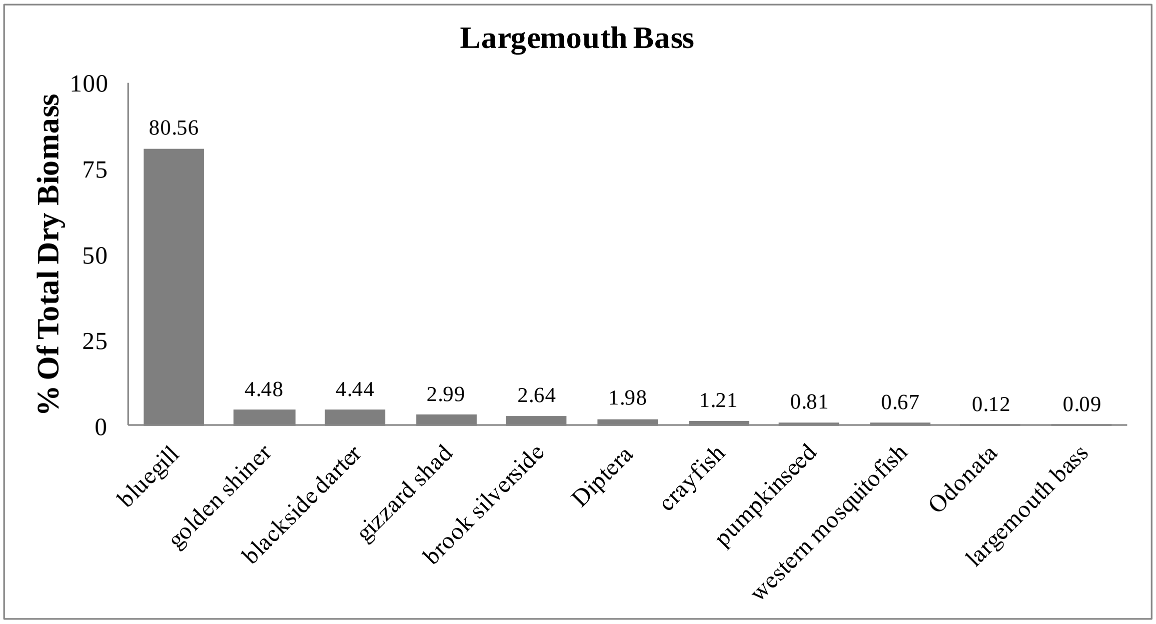
Total fish	**5148**
Species	**28**
Families	**14**



<u>Figure 1D.</u> % of total dry biomass of each prey item collected from 179 bowfin *Amia calva* at Reelfoot Lake in 2012.



<u>Figure 2D.</u> % of total dry biomass of each prey item collected from 76 spotted gar *Lepisosteus oculatus* at Reelfoot Lake in 2012.



<u>Figure 3D.</u> % of total dry biomass of each prey item collected from 48 largemouth bass *Micropterus salmoides* at Reelfoot Lake in 2012.

<u>Appendix E. 2012 Wisconsin lakes Summary</u>

Authors: T.D. VanMiddlesworth*, Bradley A. Ray, Greg G. Sass, and Timothy W. Spier

Introduction

We sampled the fish communities at four southeastern Wisconsin lakes including Eagle Spring Lake, Lulu Lake, Upper Phantom Lake, and Lower Phantom Lake in order to compare these systems with the Emiquon Preserve and Reelfoot Lake. These four lakes each have diverse fish and aquatic vegetation communities. They are similar to the Emiquon Preserve and Reelfoot Lake in that they maintain a non-native population consisting of common carp *Cyprinus carpio*. Each of the four lakes native plant and animal communities seem to co-exist with the non-native fish community, while maintaining sufficient water clarity to produce dense aquatic vegetation communities. Our primary objective was to determine prey use of the most abundant piscivores in the systems, which included largemouth bass *Micropterus salmoides* and bowfin *Amia calva*, to determine if these fishes were preying upon common carp (Heussner et al. 2008, 2009).

Methods

We sampled the fish communities at Eagle Spring Lake, Lulu Lake, Upper Phantom Lake, and Lower Phantom Lake from 7/09/2012-7/10/2012. All four lakes are located near Mukwonago in southeastern Wisconsin. Eagle Spring Lake has a surface area of about 112 ha with an average depth of 3.6 ft, while Lulu Lake is about 38 ha with an average depth of 24 ft (Eagle Spring Lake Management District 2011). Upper Phantom Lake is about 44 ha with an average depth of 11 ft, while Lower Phantom Lake is about 150 ha with an average depth of 4 ft (Upper and Lower Phantom lakes Management District 2012). Fish sampling was based on the U.S. Army Corps' of Engineers Upper Mississippi River Restoration-Environmental Management Program (UMMR-EMP) Long Term Resource Monitoring Program (LTRMP) element protocols (Gutreuter et al. 1995).

Fish

We used pulsed-DC electrofishing to sample fish along the entire shoreline of all four lakes. Largemouth bass, bowfin, grass pickerel, northern pike, and common carp were measured to the nearest mm and weighed to the nearest gram. All other species were identified and enumerated only. Diets were extracted from largemouth bass, bowfin, grass pickerel, and northern pike using a non-lethal gastric lavage technique.

Results

Fish Catch (Eagle Spring Lake)

We collected 96 fishes consisting of 8 species and 5 families while electrofishing. Largemouth bass dominated the catch with 32 fish comprising 33.3% of the total catch followed by bluegill *Lepomis macrochirus* (18, 18.8%), common carp (14, 14.6%), pumpkinseed *L. gibbosus* (10, 10.4%), warmouth *L. gulosus* (8, 8.3%), yellow bullhead *Ameiurus natalis* (7, 7.3%), yellow perch *Perca flavescens* (4, 4.2%), and lake chubsucker *Erimyzon sucetta* (3, 3.1%). Common carp was the only non-native species collected. No young-of-year (YOY) (<100 mm) common carp were collected during our sampling of Eagle Spring Lake in 2012 (Table 1E).

Catch per unit effort was calculated based on 2.1 hrs of electrofishing (pedal time). Largemouth bass dominated the catch with 15 fish/hr followed by 9 bluegill/hr, 7 common carp/hr, 5 pumpkinseed/hr, 4 warmouth/hr, 3 yellow bullhead/hr, 2 yellow perch/hr, and 1 lake chubsucker/hr. (Table 1E).

Fish Catch (Lulu Lake)

We collected 326 fishes consisting of 15 species and 8 families while electrofishing. Bluegill dominated the catch with 161 fish comprising 49.4% of the total catch followed by largemouth bass (69, 21.2%), yellow perch (31, 9.5%), warmouth (18, 5.5%), rock bass *Ambloplites rupestris* (13, 4.0%), pumpkinseed (9, 2.8%), bluntnose minnow *Pimephales notatus* (7, 2.1%), grass pickerel (6, 1.8%), yellow bullhead (5, 1.5%), golden shiner *Notemigonus crysoleucas* (2, 0.6%), brook silverside *Labidesthes sicculus* (1, 0.3%), common carp (1, 0.3%), central mudminnow *Umbra limi* (1, 0.3%), Iowa darter *Etheostoma exile* (1, 0.3%), and lake chubsucker (1, 0.3%). Common carp was the only non-native species collected. No YOY (<100 mm) common carp were collected during our sampling of Lulu Lake in 2012 (Table 2E).

Catch per unit effort was calculated based on 1.3 hrs of electrofishing (pedal time). Bluegill dominated the catch with 124 fish/hr followed by 53 largemouth bass/hr, 24 yellow perch/hr, 14 warmouth/hr, 10 rock bass/hr, 7 pumpkinseed/hr, 5 bluntnose minnow and grass pickerel/hr, 4 yellow bullhead/hr, 2 golden shiner/hr, and 1 brook silverside, common carp, central mudminnow, Iowa darter, and lake chubsucker/hr. (Table 2E).

Fish Catch (Upper Phantom Lake)

We collected 175 fishes consisting of 15 species and 7 families while electrofishing. Bluegill dominated the catch with 104 fish comprising 59.4% of the total catch followed by largemouth bass (23, 13.1%), yellow perch (10, 5.7%), warmouth (9, 5.1%), rock bass (6, 3.4%), lake chubsucker (5, 2.9%), brook silverside (3, 1.7%), grass pickerel (3, 1.7%), pumpkinseed (3, 1.7%), yellow bullhead (3, 1.7%), northern pike (2, 1.1%), blackchin shiner *Notropis heterodon* (1, 0.6%), bluntnose minnow (1, 0.6%), golden shiner (1, 0.6%), and green sunfish *L. cyanellus* (1, 0.6%). Non-native species were not collected during our sampling of Upper Phantom Lake in 2012 (Table 3E).

Catch per unit effort was calculated based on 1.1 hrs of electrofishing (pedal time). Bluegill dominated the catch with 95 fish/hr followed by 21 largemouth bass/hr, 9 yellow perch/hr, 8 warmouth/hr, 5 rock bass and lake chubsucker/hr, 3 brook silverside, grass pickerel, pumpkinseed, and yellow bullhead/hr, 2 northern pike/hr, and 1 blackchin shiner, bluntnose minnow, golden shiner, and green sunfish/hr. (Table 3E).

Fish Catch (Lower Phantom Lake)

We collected 286 fishes consisting of 15 species and 7 families while electrofishing. Bluegill dominated the catch with 65 fish comprising 22.7% of the total catch followed by lake chubsucker (61, 21.3%), pumpkinseed (31, 10.8%), yellow perch (29, 10.1%), bowfin (25, 8.7%), largemouth bass (15, 5.2%), warmouth (14, 4.9%), yellow bullhead (14, 4.9%), grass pickerel (11, 3.8%), bluntnose minnow (10, 3.5%), black bullhead *A. melas* (3, 1.0%), northern pike (3, 1.0%), golden shiner (2, 0.7%), white sucker *Catostomus commersoni* (2, 0.7%), and common carp (1, 0.3%). Common carp was the only non-native species collected. No YOY (<100 mm) common carp were collected during our sampling of Lulu Lake in 2012 (Table 4E).

Catch per unit effort was calculated based on 2.8 hrs of electrofishing (pedal time). Bluegill dominated the catch with 23 fish/hr followed by 22 lake chubsucker/hr, 11 pumpkinseed/hr, 10 yellow perch/hr, 9 bowfin/hr, 5 largemouth bass, warmouth, and yellow bullhead/hr, 4 grass pickerel and bluntnose minnow/hr, 1 black bullhead, northern pike, golden shiner, and white sucker/hr, and <1 common carp/hr (Table 4E).

Fish Diets (Eagle Spring Lake, Lulu Lake, Upper Phantom Lake, Lower Phantom Lake)

We collected 31 largemouth bass diets from Eagle Spring Lake, 30 largemouth bass diets from Lulu Lake, 16 largemouth bass diets from Upper Phantom Lake, and from Lower Phantom Lake we collected 25 bowfin and 7 largemouth bass diets during 2012. Out of these diets, we found no evidence of predation on common carp (Figure 1E, 2E, 3E, 4E, 5E).

Discussion

Eagle Spring Lake, Lulu Lake, Upper Phantom Lake, and Lower Phantom Lake displayed diverse fish communities dominated by native species. Common carp catches were low, but present in each lake except Upper Phantom Lake. Submersed, emergent, and floating leaved aquatic vegetation was present at each lake with submersed being the dominant type. The plant and animal communities seem to co-exist with common carp while maintaining sufficient water clarity to produce dense aquatic vegetation communities. We did not find evidence for common carp predation in our diet analyses. However, the data collected may reveal a mechanism as to how these four lakes have maintained a healthy ecosystem for so many years while being inhabited by common carp. These four lakes serve as model ecosystems to compare to the Emiquon Preserve. Although this was only a two day study, our observations and collections may suggest that these four lakes may be balanced aquatic ecosystems where native fish species control non-native common carp indirectly through unknown pathways and inhibit them from having negative effects on these ecosystems.

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Table 1E. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Eagle Spring Lake in 2012; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	largemouth bass	*Micropterus salmoides*	Centrarchidae	32	33.3	15
	bluegill	*Lepomis macrochirus*	Centrarchidae	18	18.8	9
*	common carp	*Cyprinus carpio*	Cyprinidae	14	14.6	7
	pumpkinseed	*L. gibbosus*	Centrarchidae	10	10.4	5
	warmouth	*L. gulosus*	Centrarchidae	8	8.3	4
	yellow bullhead	*Ameiurus natalis*	Ictaluridae	7	7.3	3
	yellow perch	*Perca flavescens*	Percidae	4	4.2	2
	lake chubsucker	*Erimyzon sucetta*	Catostomidae	3	3.1	1

Total fish	**96**
Species	**8**
Families	**5**

Table 2E. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Lulu Lake in 2012; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	bluegill	*Lepomis macrochirus*	Centrarchidae	161	49.4	124
	largemouth bass	*Micropterus salmoides*	Centrarchidae	69	21.2	53
	yellow perch	*Perca flavescens*	Percidae	31	9.5	24
	warmouth	*L. gulosus*	Centrarchidae	18	5.5	14
	rock bass	*Ambloplites rupestris*	Centrarchidae	13	4.0	10
	pumpkinseed	*L. gibbosus*	Centrarchidae	9	2.8	7
	bluntnose minnow	*Pimephales notatus*	Cyprinidae	7	2.1	5
	grass pickerel	*Esox americanus*	Esocidae	6	1.8	5
	yellow bullhead	*Ameiurus natalis*	Ictaluridae	5	1.5	4
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	2	0.6	2
	brook silverside	*Labidesthes sicculus*	Atherinidae	1	0.3	1
*	common carp	*Cyprinus carpio*	Cyprinidae	1	0.3	1
	central mudminnow	*Umbra limi*	Umbridae	1	0.3	1
	Iowa darter	*Etheostoma exile*	Percidae	1	0.3	1
	lake chubsucker	*Erimyzon sucetta*	Catostomidae	1	0.3	1

Total fish	**326**
Species	**15**
Families	**8**

Table 3E. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Upper Phantom Lake in 2012; * represents non-native species.

Common name	Scientific name	Family	No.	%	CPUE
bluegill	*Lepomis macrochirus*	Centrarchidae	104	59.4	95
largemouth bass	*Micropterus salmoides*	Centrarchidae	23	13.1	21
yellow perch	*Perca flavescens*	Percidae	10	5.7	9
warmouth	*L. gulosus*	Centrarchidae	9	5.1	8
rock bass	*Ambloplites rupestris*	Centrarchidae	6	3.4	5
lake chubsucker	*Erimyzon sucetta*	Catostomidae	5	2.9	5
brook silverside	*Labidesthes sicculus*	Atherinidae	3	1.7	3
grass pickerel	*Esox americanus*	Esocidae	3	1.7	3
pumpkinseed	*L. gibbosus*	Centrarchidae	3	1.7	3
yellow bullhead	*Ameiurus natalis*	Ictaluridae	3	1.7	3
northern pike	*E. lucius*	Esocidae	2	1.1	2
blackchin shiner	*Notropis heterodon*	Cyprinidae	1	0.6	1
bluntnose minnow	*Pimephales notatus*	Cyprinidae	1	0.6	1
golden shiner	*Notemigonus crysoleucas*	Cyprinidae	1	0.6	1
green sunfish	*L. cyanellus*	Centrarchidae	1	0.6	1

Total fish	**175**
Species	**15**
Families	**7**

Table 4E. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Lower Phantom Lake in 2012; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	bluegill	*Lepomis macrochirus*	Centrarchidae	65	22.7	23
	lake chubsucker	*Erimyzon sucetta*	Catostomidae	61	21.3	22
	pumpkinseed	*L. gibbosus*	Centrarchidae	31	10.8	11
	yellow perch	*Perca flavescens*	Percidae	29	10.1	10
	bowfin	*Amia calva*	Amiidae	25	8.7	9
	largemouth bass	*Micropterus salmoides*	Centrarchidae	15	5.2	5
	warmouth	*L. gulosus*	Centrarchidae	14	4.9	5
	yellow bullhead	*Ameiurus natalis*	Ictaluridae	14	4.9	5
	grass pickerel	*Esox americanus*	Esocidae	11	3.8	4
	bluntnose minnow	*Pimephales notatus*	Cyprinidae	10	3.5	4
	black bullhead	*A. melas*	Ictaluridae	3	1.0	1
	northern pike	*E. lucius*	Esocidae	3	1.0	1
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	2	0.7	1
	white sucker	*Catostomus commersoni*	Catostomidae	2	0.7	1
*	common carp	*Cyprinus carpio*	Cyprinidae	1	0.3	<1

Total fish	**286**
Species	**15**
Families	**7**

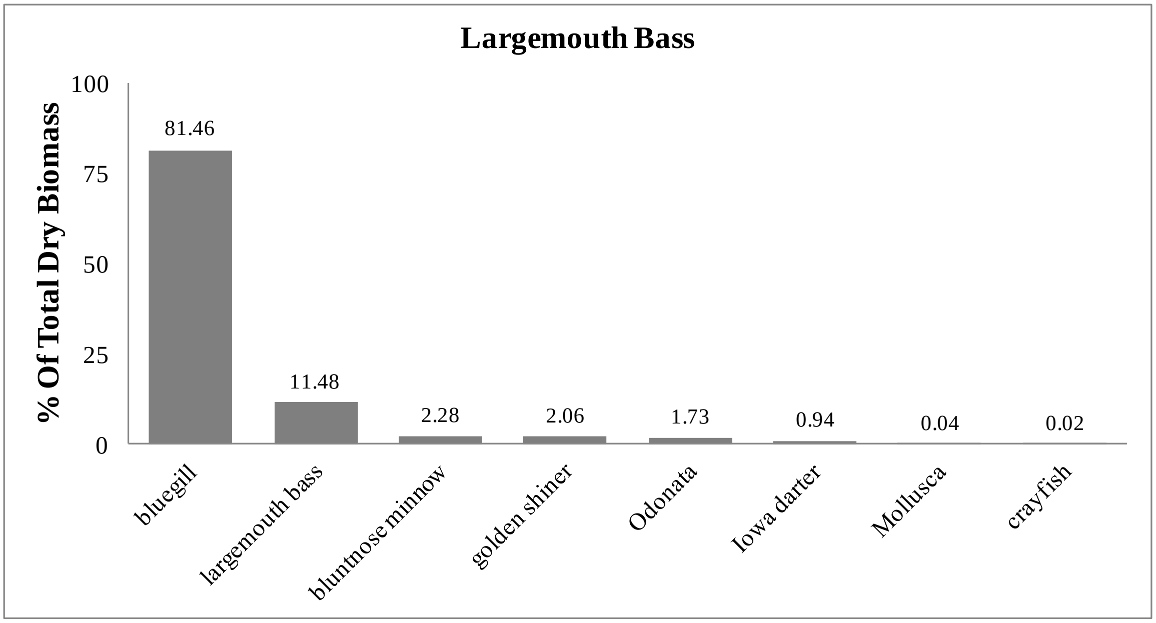


Figure 1E. % of total dry biomass of each prey item collected from 31 largemouth bass *Micropterus salmoides* at Eagle Spring Lake in 2012.

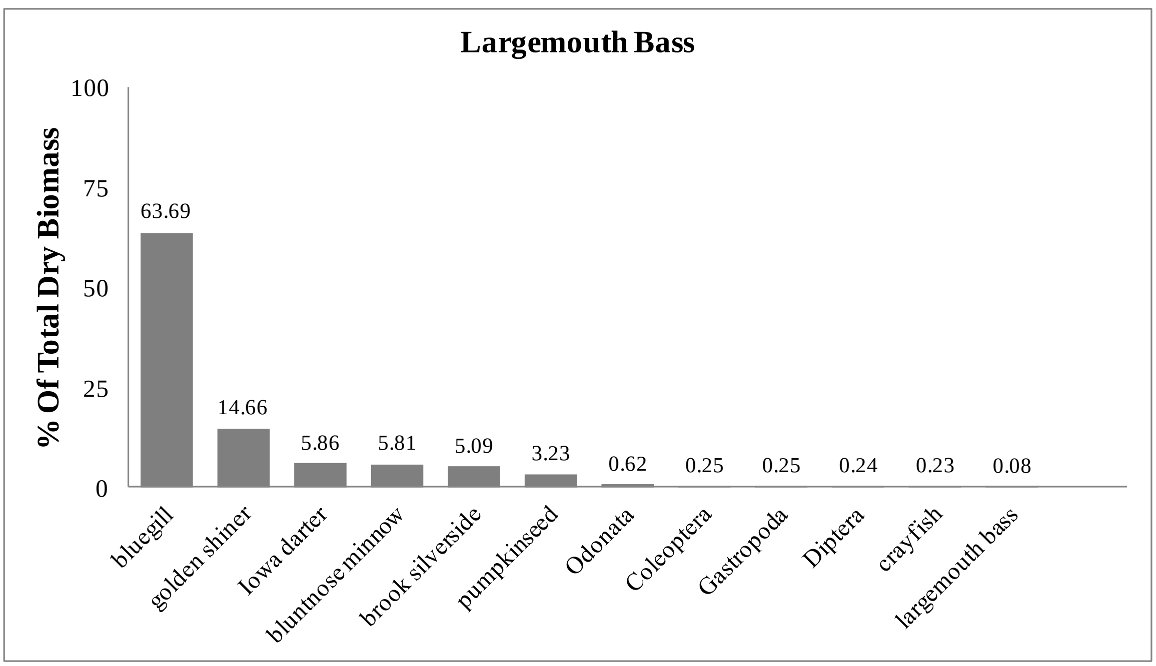
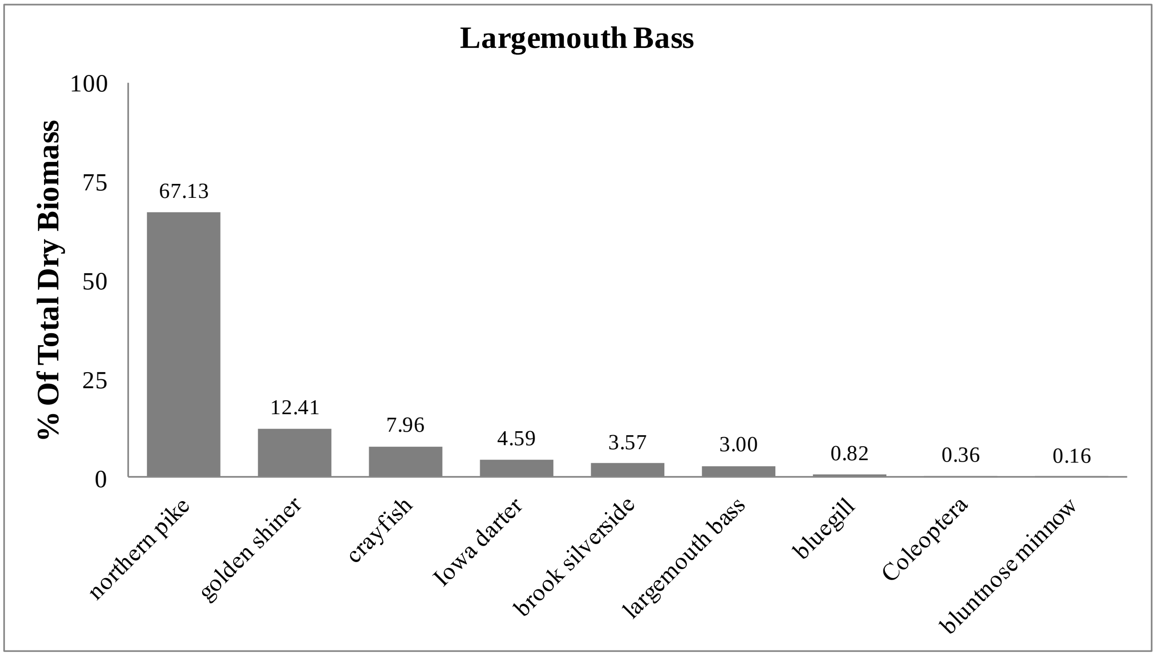
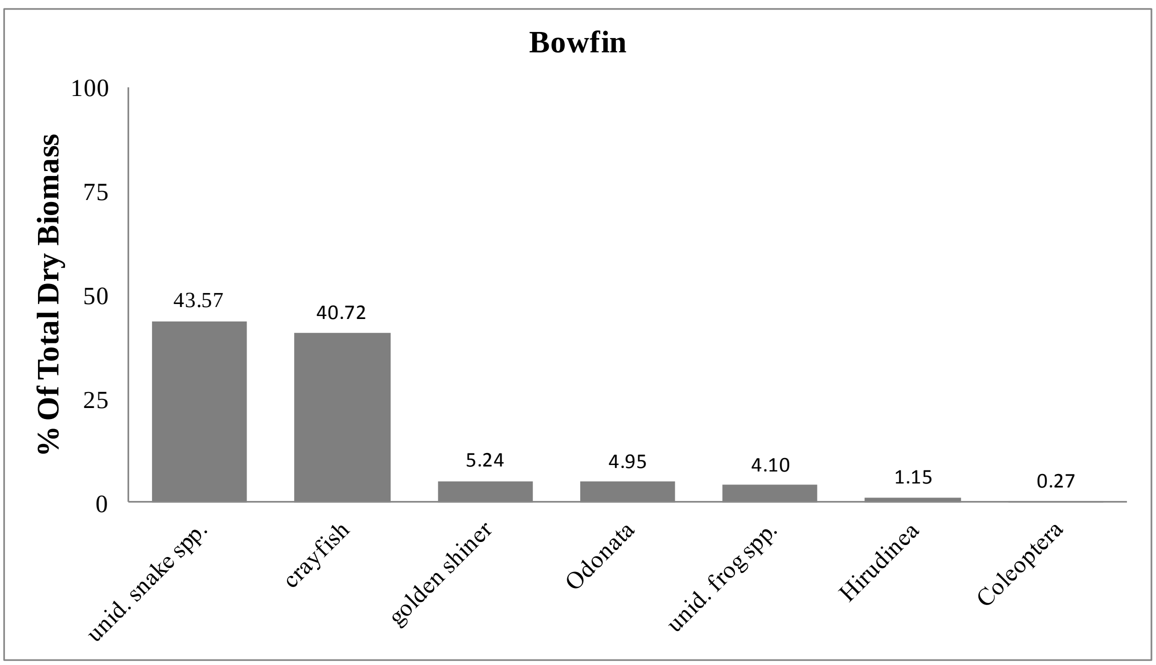


Figure 2E. % of total dry biomass of each prey item collected from 30 largemouth bass *Micropterus salmoides* at Lulu Lake in 2012.



<u>Figure 3E.</u> % of total dry biomass of each prey item collected from 16 largemouth bass *Micropterus salmoides* at Upper Phantom Lake in 2012.



<u>Figure 4E.</u> % of total dry biomass of each prey item collected from 25 bowfin *Amia calva* at Lower Phantom Lake in 2012.

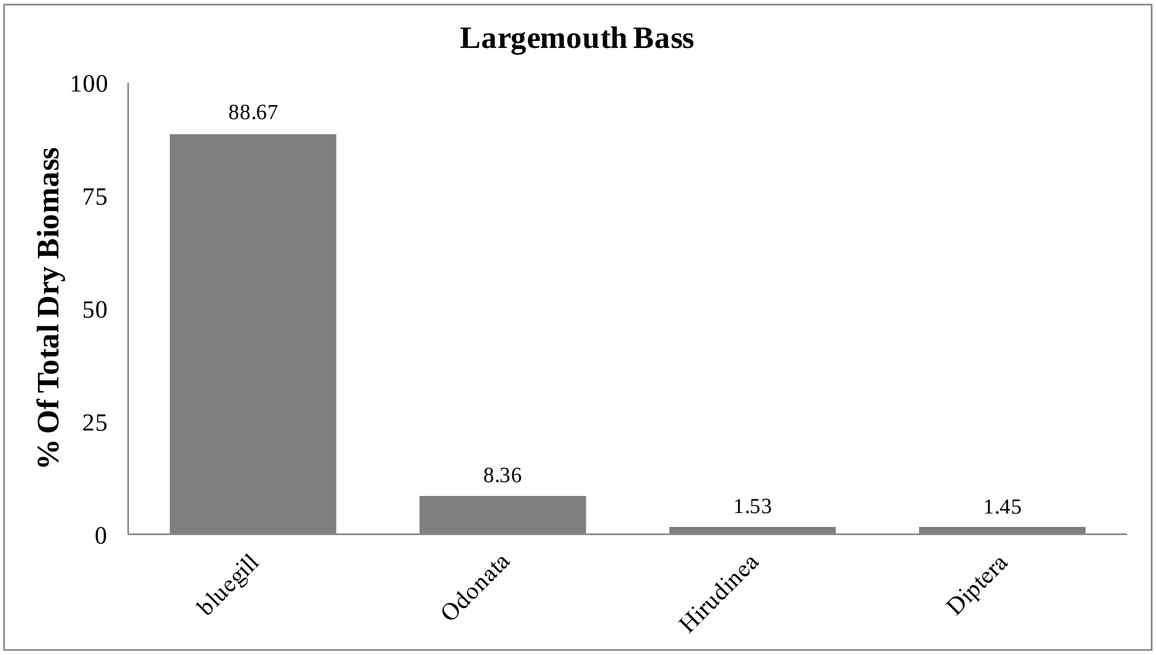


Figure 5E. % of total dry biomass of each prey item collected from 7 largemouth bass *Micropterus salmoides* at Lower Phantom Lake in 2012.

Appendix F. 2013 Reelfoot Lake Summary

Authors: T.D. VanMiddlesworth*, Bradley A. Ray, Greg G. Sass, and Timothy W. Spier

Introduction

We sampled the fish community at Reelfoot Lake to expand upon our 2011-2012 findings and compare the system with the Emiquon Preserve and 4 southeastern Wisconsin lakes. Reelfoot Lake has diverse fish and aquatic vegetation communities. It is similar to the Emiquon Preserve and other Illinois River backwater lakes in that it is a shallow floodplain lake that is disconnected from the mainstem river and maintains a non-native fish community including common carp *Cyprinus carpio*. However, the native plant and fish communities seem to co-exist with the non-native fish community, while maintaining sufficient water clarity to produce dense aquatic vegetation in Reelfoot Lake. Our primary objective was to determine prey use of the most abundant piscivores in the system, which included bowfin *Amia calva,* largemouth bass *Micropterus salmoides,* and spotted gar *Lepisosteus oculatus* to test whether these fishes were preying upon common carp (TWRA 2009).

Methods

We sampled the fish communities at Reelfoot Lake extensively from 4/4/2013-8/13/2013. Reelfoot Lake is located near Samburg, TN, has a surface area of about 6,070 ha, and was formed in the early 1800s by a massive earthquake. The average depth is 5.2 feet (THS 2013) (TWRA, 2009, 2013). Fish sampling was based on the U.S. Army Corps of Engineers Upper Mississippi River Restoration-Environmental Management Program (UMMR-EMP) Long Term Resource Monitoring Program (LTRMP) element protocols (Gutreuter et al. 1995).

Fish

We used pulsed-DC electrofishing to sample fish at 163 sites in a variety of habitats for 15 minutes each. Largemouth bass, bowfin, channel catfish *Ictaluris punctatus*, shortnose gar *Lepisosteus platostomus*, spotted gar, channel catfish and common carp were measured to the nearest mm and weighed to the nearest gram. Only length was collected for young-of-year (YOY) common carp and YOY spotted gar. All other species were identified and enumerated only. Diets were extracted from bowfin, channel catfish, shortnose gar, and spotted gar by removing the entire gut of each fish, preserved in formalin, and stored for lab analysis. Largemouth bass diets were collected using a non-lethal gastric lavage technique.

Water Quality

Ancillary water quality measurements (surface water temperature (^{o}C), dissolved oxygen (ppm), conductivity (µS)) were taken at each site using a YSI 85.

Results

Fish Catch

We collected 13,365 fishes consisting of 39 species and 14 families while electrofishing. Gizzard shad *Dorosoma cepedianum* dominated the catch with 8,882 fish comprising 66.5% of the total catch followed by bluegill *Lepomis macrochirus* (801, 6.0%), freshwater drum *Aplodinotus grunniens* (502, 3.8%), yellow bass *Morone mississippiensis* (381, 2.9%), golden shiner *Notemigonus crysoleucas* (365, 2.7%), bowfin (340, 2.5%), largemouth bass (291, 2.2%), channel catfish (276, 2.1%), common carp (240, 1.8%), brook silverside *Labidesthes sicculus* (209, 1.6%), orangespotted sunfish *L. humilis* (154, 1.2%), warmouth *L. gulosus* (147, 1.1%), black crappie *Pomoxis nigromaculatus* (123, 0.9%), spotted gar (119, 0.9%), unidentified *Pomoxis* spp. (likely white or black crappie) (113, 0.8), western mosquitofish *Gambusia affinis* (71, 0.5%), bigmouth buffalo *Ictiobus cyprinellus* (67, 0.5%), white crappie *P. annularis* (51, 0.4%), longear sunfish *L. megalotis* (29, 0.2%), flier *Centrarchus macropterus* (28, 0.2%), pirate perch *Aphredoderus sayanus* (28, 0.2%), unidentified Catostomidae spp. (likely buffalo spp.) (26, 0.2%), unidentified *Lepomis* spp. (likely bluegill or pumpkinseed) (22, 0.2%), black buffalo *I. niger* (21, 0.2%), chain pickerel *Esox niger* (20, 0.1%), golden topminnow *Fundulus chrysotus* (16, 0.1%), grass pickerel *E. americanus* (12, 0.1%), brown bullhead *Ameiurus nebulosus* (5, <0.1%), smallmouth buffalo *I. bubosus* (5, <0.1%), yellow bullhead *A. natalis* (5, <0.1%), blackspotted topminnow *F. olivaceus* (3, <0.1%), taillight shiner *Notropis maculates* (3, <0.1%), unidentified Ictaluridae spp. (likely channel catfish) (3, <0.1%), shortnose gar (2, <0.1%), blacknose crappie *P. nigromaculatus* (1, <0.1%), dollar sunfish *L. marginatus* (1, <0.1%), green sunfish *L. cyanellus* (1, <0.1%), silver carp *Hypopthalmichthys molitrix* (1, <0.1%), and unidentified Cyprinidae spp. (non-carp spp.) (1, <0.1%). Non-native species collected included common carp and silver carp. No YOY (<100 mm) silver carp were collected but we did collect 141 YOY common carp (20-90 mm) during our sampling of Reelfoot Lake in 2013 (Table 1F).

Gizzard shad dominated the catch with 218 fish/hr followed by 20 bluegill/hr, 12 freshwater drum/hr, 9 yellow bass and golden shiner/hr, 8 bowfin/hr, 7 largemouth bass and channel catfish/hr, 6 common carp/hr, 5 brook silverside/hr, 4 orangespotted sunfish and warmouth/hr, 3 black crappie, spotted gar, and unidentified *Pomoxis* spp./hr (likely white or black crappie), 2 western mosquitofish and bigmouth buffalo/hr, 1 white crappie, longear sunfish, flier, pirate perch, unidentified Catostomidae spp. (likely buffalo spp.), unidentified *Lepomis* spp. (likely bluegill or pumpkinseed), and black buffalo/hr, <1 chain pickerel, golden topminnow, grass pickerel, brown bullhead, smallmouth buffalo, yellow bullhead, blackspotted topminnow, taillight shiner, unidentified Ictaluridae spp. (likely channel catfish), shortnose gar, blacknose crappie *P. nigromaculatus*, dollar sunfish *L. marginatus*, green sunfish, silver carp, and unidentified Cyprinidae spp. (non-carp spp.)/hr (Table 1F).

Fish Diets

We collected 286 bowfin, 242 channel catfish, 104 shortnose/spotted gar, and 80 largemouth bass diets from Reelfoot Lake during 2013. Diet results are coming soon.

Water Quality

In 2013, we recorded water quality parameters at all 163 electrofishing sites. On average, water temperature was 23.8 °C, dissolved oxygen was 3.4 ppm, and depth was 1.0 m. Secchi disc transparencies had a mean of 51 cm. Secchi disc transparencies were ≥half the maximum water depth 61% of the time.

Discussion

Reelfoot Lake had a largemouth bass CPUE less than that of the Emiquon Preserve and bowfin and spotted gar CPUE greater than that of the Emiquon Preserve. Fish species richness was much greater at Reelfoot Lake than at the Emiquon Preserve. Emergent aquatic vegetation was abundant at Reelfoot Lake, whereas submersed aquatic vegetation was abundant at the Emiquon Preserve. Other structure, including woody debris density, was greater at Reelfoot Lake than at the Emiquon Preserve.

The above mentioned differences along with our diet analyses may reveal a mechanism as to how this shallow lake has maintained a healthy aquatic ecosystem for so many years while being inhabited by common carp. Reelfoot Lake serves as a model ecosystem to compare to the Emiquon Preserve. Our data collections may suggest that Reelfoot Lake may be a balanced aquatic ecosystem where native fish species control non-native common carp and inhibit them from having negative effects on the ecosystem. In order to learn more, additional research is necessary.

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Table 1F. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Reelfoot Lake in 2013; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	gizzard shad	*Dorosoma cepedianum*	Clupeidae	8882	66.5	218
	bluegill	*Lepomis macrochirus*	Centrarchidae	801	6.0	20
	freshwater drum	*Aplodinotus grunniens*	Sciaenidae	502	3.8	12
	yellow bass	*Morone mississippiensis*	Moronidae	381	2.9	9
	golden shiner	*Notemigonus crysoleucas*	Cyprinidae	365	2.7	9
	bowfin	*Amia calva*	Amiidae	340	2.5	8
	largemouth bass	*Micropterus salmoides*	Centrarchidae	291	2.2	7
	channel catfish	*Ictalurus punctatus*	Ictaluridae	276	2.1	7
*	common carp	*Cyprinus carpio*	Cyprinidae	240	1.8	6
	brook silverside	*Labidesthes sicculus*	Atherinopsidae	209	1.6	5
	orangespotted sunfish	*L. humilis*	Centrarchidae	154	1.2	4
	warmouth	*L. gulosus*	Centrarchidae	147	1.1	4
	black crappie	*Pomoxis nigromaculatus*	Centrarchidae	123	0.9	3
	spotted gar	*Lepisosteus oculatus*	Lepisostidae	119	0.9	3
	unidentified *Pomoxis* spp.	*Pomoxis* spp.	Centrarchidae	113	0.8	3
	western mosquitofish	*Gambusia affinis*	Poeciliidae	71	0.5	2
	bigmouth buffalo	*Ictiobus cyprinellus*	Catostomidae	67	0.5	2
	white crappie	*P. annularis*	Centrarchidae	51	0.4	1
	longear sunfish	*L. megalotis*	Centrarchidae	29	0.2	1
	flier	*Centrarchus macropterus*	Centrarchidae	28	0.2	1
	pirate perch	*Aphredoderus sayanus*	Aphredoderidae	28	0.2	1
	unidentified Catostomidae spp.	*Ictiobus* spp.	Catostomidae	26	0.2	1
	unidentified *Lepomis* spp.	*Lepomis* spp.	Centrarchidae	22	0.2	1
	black buffalo	*I. niger*	Catostomidae	21	0.2	1
	chain pickerel	*Esox niger*	Esocidae	20	0.1	<1
	golden topminnow	*Fundulus chrysotus*	Fundulidae	16	0.1	<1
	grass pickerel	*E. americanus vermiculatus*	Esocidae	12	0.1	<1
	brown bullhead	*Ameiurus nebulosus*	Ictaluridae	5	0	<1
	smallmouth buffalo	*I. bubalus*	Catostomidae	5	0	<1
	yellow bullhead	*A. natalis*	Ictaluridae	5	0	<1
	blackspotted topminnow	*F. olivaceus*	Fundulidae	3	0	<1
	taillight shiner	*Notropis maculatus*	Cyprinidae	3	0	<1
	unidentified Ictaluridae spp.	Ictaluridae spp.	Ictaluridae	3	0	<1
	shortnose gar	*L. platostomus*	Lepisostidae	2	0	<1
	blacknose crappie	*P. nigromaculatus*	Centrarchidae	1	0	<1
	dollar sunfish	*L. marginatus*	Centrarchidae	1	0	<1

Table 1F Continued. Fish species list showing total catch, percent composition of total catch, and catch per unit effort (CPUE) for each species collected at Reelfoot Lake in 2013; * represents non-native species.

	Common name	Scientific name	Family	No.	%	CPUE
	green sunfish	*L. cyanellus*	Centrarchidae	1	0	<1
*	silver carp	*Hypopthalmichthys molitrix*	Cyprinidae	1	0	<1
	unidentified Cyprinidae spp.	Cyprinidae spp.	Cyprinidae	1	0	<1

Total fish	**13365**
Species	**39**
Families	**14**